

**SIMULATION OF TACTICAL  
ALTERNATIVE RESPONSES  
(STAR)**

**William Scott Wallace**



# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



# THESIS

SIMULATION OF TACTICAL  
ALTERNATIVE RESPONSES  
(STAR)

by

William Scott Wallace  
and

Eugene Gordon Hagewood

December 1978

Thesis Advisors: S. A. Perry  
E. P. Kelleher

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(continuation of abstract)

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Simulation of Tactical  
Alternative Responses  
(STAR)

/ by

William Scott Wallace  
Captain, United States Army  
B.S., United States Military Academy, 1969

and

Eugene Gordon Hagewood  
Captain, United States Army  
B.S., Georgia Institute of Technology, 1969

Submitted in partial fulfillment of the  
requirements for the degree of

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## ABSTRACT

This thesis presents a stochastic simulation model of ground combat. The tactics represented in this model are explained in detail, and a brief explanation of the SIMSCRIPT programming language used in the model is presented. The model is explained in detail, and the computer routines which make up the model are included. The input requirements for execution of the model are explained in detail so that this thesis might become the initial user's manual for future applications of the model. A typical simulated battle is presented with detailed explanation of the output to enable the reader to better appreciate the potential applications of the model. The current status of the model referenced in this thesis is prior to the version which will be used for production runs.



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## I. INTRODUCTION

During the past several decades, the nature of battle has changed, not abruptly, but nonetheless significantly. The fact that the modern battlefield will be dominated by highly lethal weapons is well known. Technologically advanced supporting systems (combat support, combat service support, communications, etc.) are being developed and sent to the field. The high cost of these systems, either weapons or supporting systems, make it imperative that once the procurement process is complete, the best possible systems are introduced into the inventory. Such systems must meet the most stringent requirements for effectiveness, trainability, and maintainability. In recent years one of the most useful tools in evaluating proposed and existing systems has been the combined arms simulation model. With these facts in mind, the Simulation of Tactical Alternative Responses (STAR) combined arms model discussed in this document has been developed.

One of the primary goals of STAR is to achieve an acceptable level of resolution while assuring that the model inputs, interactions, and outputs are understood by the military decision maker. It is the intent of this thesis to outline the structure of STAR in sufficient detail to allow analysts and decision makers to fully understand the execution logic of the model, and thus understand the results of the model and how these results were derived.



The structure of STAR is truly hierarchical in that it is not confined to any specific unit size configuration. The SIMSCRIPT programming language has been chosen as the primary language for STAR. The reasons for selection of SIMSCRIPT and a brief discussion of those SIMSCRIPT programming features which are utilized in the model are discussed in Chapter II.

The BLUE and RED tactics modeled in the current version of STAR are discussed in chapter III. This chapter describes the assumptions made in regard to the tactics employed by individual weapon systems and unit organizations. The chapter also states, in general terms, how these tactics have been modeled.

Chapter IV is an in-depth discussion of the SIMSCRIPT events and routines which make up the model. Included in chapter IV is a discussion of each individual routine, an explanation of the variables used in the routine, a listing of the computer code for the routine and a line by line explanation of what the code does. Also included in chapter IV is a discussion of the PREAMBLE and MAIN programs of the model which prepare the model for execution.

Chapter V is a detailed discussion of the input requirements of the model. Included are specifications of the SIMSCRIPT inputs required and the job control language required to run the model. Proper formatting of the input and an explanation of the meaning of each block of input is also included.





Chapter VI is a simulated battle run using the current version of the STAR model. The progress of the battle is traced over time to show the reader the format of the model output and allow the reader to see what type of output could be expected from the model.

The current version of STAR utilizes a parametric terrain model developed by Needels [Ref. 8] while a student at the Naval Postgraduate School, and since enhanced by Needels and Professor James K. Hartman of the Naval Postgraduate School. The parametric terrain model provides a truly continuous terrain as opposed to the digitized terrain used in some existing models.

The model addressed in this thesis is, in a sense, an interim product. Work is continuing at the Naval Postgraduate School on a dynamic artillery module to be included in the model by mid-December 1978. Dynamic play of BLUE and RED air defense and close air support, as well as a detailed communications module, will be available by mid-April 1979. Enhancement of the existing model will continue through mid-1979 with the ultimate goal of providing a BLUE Brigade versus RED Division simulation which employs all those modules mentioned above plus the dynamic play of resupply at the unit and individual vehicle level. These enhancements are described in chapter VII.

Appendix A is a flowchart which represents the event flow of a single tank as the tank cycles through the simulation. Appendix B is a glossary of terms used in the thesis.



Throughout the thesis, repeated references are made to the "current version of STAR". The purpose of this thesis is to describe the logic flow of the model within the context of the current model status prior to incorporation of many detailed features required for production runs. Therefore, the reader must not consider this thesis as a documentation of the production version of the model. Such a document will be produced as a Naval Postgraduate School Technical Report in early 1979.

In order to exercise the logic of the model, many assumptions were made concerning tactics employed by both the attacking and defending forces. These assumptions were made based on the experience of the authors, both combat and non-combat, and were in general validated by an appropriate agency of the United States Army Training and Doctrine Command. Tactical decision making, combat intelligence, command and control, and tactical communications networks are not specifically modeled, but are addressed in the discussion of tactical assumptions. It should be obvious that this model is not a full representation of actual combat. Modeling simplifications have been made in several areas. However, none of these simplifications should be considered critical to the validity of the model.



## II. THE USE OF SIMSCRIPT IN STAR

### General

The SIMSCRIPT language, level II.5, was selected for STAR because the language is designed for discrete event simulation applications. Because of the many imbedded features in SIMSCRIPT, the programmer is given opportunities in the construction of event flow which are not available in FORTRAN or other computation languages. SIMSCRIPT is also similar to English in regard to the construction of commands and the implementation of logical tests. This feature, coupled with an essentially free form of syntax, allows the code to be written in a very readable format. This will become apparent when the coding for the events and routines in STAR is introduced.

Also important to the programmer is the similarity of SIMSCRIPT to FORTRAN with regard to computational syntax. A programmer with a moderate amount of experience in FORTRAN should have very few difficulties understanding and writing computational routines in SIMSCRIPT.

Finally, since a wide variety of computational routines exist in FORTRAN (terrain models, line of sight routines, smoke models, lethality packages, etc.), it is important that any simulation provide some reasonable interface with these existing modules. SIMSCRIPT provides this capability



by allowing FORTRAN routines to be called as subroutines by SIMSCRIPT events and routines.

This last feature made SIMSCRIPT an even more appealing language, since existing FORTRAN routines can be used with only minor modifications. The difficult line of sight calculations, for example, are accomplished in FORTRAN because the terrain model used by STAR was originally written in FORTRAN. Other routines which were more closely tied to the structure of SIMSCRIPT were written in that language. The routine that updates the list of detected targets for each TANK, for example, is written in SIMSCRIPT to take advantage of the dynamic dimensioning capability of the language and the pointer value link listing techniques available. For large target arrays, these SIMSCRIPT language features are extremely efficient in reducing core storage requirements and execution time.

#### Main Structural Components of SIMSCRIPT

The primary imbedded simulation facilities available to STAR are structural components known as entities, attributes, sets, and events. These components are used in conjunction with an internal timing mechanism which is referred to as the system timer throughout this thesis. These facilities greatly simplify the process of writing a simulation program and debugging code. The process is further simplified by a compiler which provides error messages and traceback routines similar to the WATFOR and WATFIV compilers in FORTRAN.





## The Structure of STAR

The structure of STAR begins with the concept of an entity. An entity is simply a representation or model of an item to be simulated. In other simulations, entities might represent people waiting in line for tickets, customers in a bank, or automobiles waiting to be serviced at a gas station. In STAR the basic entities are weapon systems representing tanks, anti-tank guided missiles, artillery pieces, and are referred to generally as TANKs. Throughout this thesis the following terms are synonymous with the notion of an entity: TANK, POINTER, FOE, element, weapon system, firer, target, and observer. Those terms which are capitalized are explicitly used as variables in the program. An entity may be brought into existence by using a simple phrase which includes the variable name of the entity. For example, the phrase CREATE A TANK reserves a place in core storage for the entity which the programmer has chosen to call TANK. Associated with the word TANK is a pointer value which defines the location in core storage where this particular TANK and information pertinent to it are stored.

It is desirable to associate certain characteristics with entities after they have been created. These characteristics are referred to as attributes and are affixed to an entity by the programmer or, as will be seen in the discussion of sets, may be placed on the entity by SIMSCRIPT bookkeeping procedures (referred to as the system). As an example of user affixed attributes, the programmer may wish



to assign a current X coordinate to a TANK. This is accomplished by the phrase: `LET X.CURRENT(TANK) = 3150`. Attributes may be changed during program execution to reflect changes in characteristics. The system changes system defined attributes as required.

In addition to associating characteristics with particular entities, it is often useful to group entities with similar characteristics. STAR uses sets to keep track of all TANKS on the battlefield for organizational and fire control purposes which enhances the programmer's ability to model unit tactics at any organizational level. An entity may belong to any number of sets and may also own sets. The following phrases illustrate set membership: `FILE TANK IN TANKS`, `FILE TANK IN COMP.UNIT(5)`. In this example the TANK is first made a member of a set called TANKS. The system automatically assigns to the TANK a membership attribute, `M.TANKS`, whose value is the integer 1. The second `FILE` command makes the TANK a member of company number 5. Again, a membership attribute (`M.COMP.UNIT`) is assigned a value of 1. Ownership of sets is accomplished by a phrase of the form: `EVERY COMPANY.COMMANDER OWNS A COMP.UNIT`. In addition, each entity filed in a set has attributes which indicate who the first and last members of the set are and how many members belong to the set. BLUE force elements are filed in platoon sets (`PLT.UNIT`), company sets (`COMP.UNIT`), and a set of operational tanks (`BLUE.ALIVE`). Although entities may be filed by ranking attributes, STAR uses a simple first-in first-out procedure. RED force elements



are assigned similarly except that their set of operational TANKs is called RED.ALIVE. All TANKs (XMI, IFVs, ITVs, DIVAD guns, DRAGONS, T72s, BMPs, and ZSUs) are assigned to a set called TANKS which is used for final output purposes.

Each entity in STAR is modeled to reflect a flow of activities over time. In particular, each entity initiates, or undergoes, search, detection, target selection, firing, impact, or location update. These six events are scheduled dynamically based on the current tactical situation or by way of an appropriate probability distribution which models the period of time between events. When an event is scheduled for an entity, the SIMSCRIPT timer makes a record of the time that the event is scheduled to occur (in terms of overall simulated time) and the entity for which the event has been scheduled. Other characteristics of the event may be recorded in a manner similar to the assignment of attributes. At the appropriate simulated time, the event is executed unless cancelled by some logic provided by the programmer. For example, the scheduling of a fire event by one TANK on another could be accomplished by the phrase: SCHEDULE A FIRE(A, ID) IN X SECONDS. The variable A represents the pointer value of the firing TANK, while ID represents the pointer value of the target TANK. This event would be filed by the system in an event set which contained, among other things, the time that the event is to take place, the entities involved in the event and the event location with respect to other scheduled events. When X seconds had elapsed from the current simulated time, the



event would be executed and the consequences of the logic written in the event routine would occur. Event routines may in turn generate other events. The FIRE event in STAR, for example, causes the scheduling of an IMPACT event. IMPACT may then cause the scheduling of DETECT and TARGET.SELECT events.

The information provided here should prepare the reader for the detailed discussion of the event and routine coding which is given in chapter IV.





### III. TACTICS MODELED IN STAR

The purpose of this chapter is to describe the tactical conventions modeled in STAR. Due to the unquantifiable nature of some of the tactics described herein, especially in the area of RED tactics, the tactics modeled in STAR represent, in some cases, a "best guess" as to how to represent the tactics of a particular system or unit organization. The actual computer code which models these tactical considerations in the simulation is outlined in detail in chapter IV.

In order to understand the tactics represented in the model, it is first necessary to understand how the weapon systems in the simulation are organized and to have some knowledge of the attributes of each of the weapons systems. As mentioned in chapter II, each weapon system simulated is a member of the set TANKS, which is a list of every element in the simulation. Each BLUE weapon system that is currently active in the simulation is a member of the set BLUE.ALIVE, likewise each active RED system is a member of a company set and a platoon set which represent the unit to which he belongs. Every weapon system in the simulation has attributes which indicate to that element which weapon system in the simulation represents his company commander, platoon leader, and section leader. Additional attributes indicate to the weapon system what type of ammunition he has available



and the number of rounds remaining. The weapon types and ammunition types available to each weapon system, and the numeric code used to represent these weapons and ammunition types are presented in table I. With this general understanding of the set and attribute structure of the model we proceed with the tactical discussion.

### Search and Detection

Search for targets takes place iteratively throughout the simulation at intervals specified by a time increment variable, DELTA.T, provided by the user. The essence of the search procedure is that every DELTA.T seconds of the simulation every weapon system will check every opposing weapon system that is still "alive" in the simulation. If the observer has line of sight to the target, the time it would take for the observer to detect the target is determined and at that future time the detected target is placed in a list of currently detected targets unique to that particular observer. No detections of greater than DELTA.T seconds are scheduled. This prevents detections from overlapping into the next search event. Detection can take place external to this normal detection process in one of two ways. First, a target that is fired on is allowed to detect the firer without going through the normal detection process. Second, those weapon systems in close proximity to a normally detected target are considered detected as well and are placed in the observer's target list.



TABLE I

WEAPON SYSTEM AND AMMUNITION CODES

| WPN. TYPE<br>ATTRIBUTE<br>CODE | WEAPON<br>SYSTEM<br>NAME | AMMUNITION CODE AND AMMUNITION ATTRIBUTE NAME |               |                   |                   |
|--------------------------------|--------------------------|---|---------------|-------------------|-------------------|
|                                |                          | 1<br>AP. TOW                                  | 2<br>HE. DRAG | 3<br>AW1. OR. MSL | 4<br>AW2. OR. ADM |
| 1*                             | XM1                      | APDS  | HEAT          | .50 Cal MG        | ---               |
| 2*                             | XM1                      | APDS  | HEAT          | .50 Cal MG        | ---               |
| 3                              | IFV                      | TOW   | ---           | Bushmaster        | ---               |
| 4                              | ITV                      | TOW   | ---           | ---               | ---               |
| 5                              | DIVAD                    | ---   | ---           | 35/40mm gun       | ---               |
| 6                              | DRAGON                   | ---   | DRAGON        | ---               | ---               |
| 7                              | T72                      | APDS  | HEAT          | 12.7mm MG         | ---               |
| 8                              | BMP                      | ATGM  | ---           | 73mm gun          | ---               |
| 9                              | ZSU                      | ---   | ---           | 37mm gun          | ---               |

Ammunition codes not utilized by a particular weapon system are indicated by 3 hyphens (---).

\*Two XM1 weapon type codes have been provided to allow for both the XM1 with 105mm main gun and the XM1 with 120mm main gun.



## Target Selection

The use of danger state tables in target selection and the computer code which simulates the selection of targets are explained in detail in later chapters. A brief explanation of the target selection process is given in this section. The distance from firer to target is currently divided into three range bands for each firing weapon system. These bands are: less than 1000 meters from the system, 1000-2000 meters from the system, and greater than 2000 meters from the system. The observer searches his list of detected targets and selects the highest priority target within the closest range band. Within range bands, targets of equal priority are selected based on closest range, which is the normal target selection process for a weapon system. This normal selection process may be overridden by special tactical considerations described in subsequent paragraphs. Current development of a more comprehensive target selection model is described in chapter VII.

### A. BLUE WEAPON SYSTEMS

#### Terrain Utilization

It is assumed that the BLUE weapon systems in defense will take maximum advantage of the available terrain. BLUE systems will assume a turret defilade position while acquiring targets, move to a firing defilade position during firing, and, after firing a specified number of rounds, move to a full defilade position which protects the system from direct fire while loading ammunition, redistributing





ammunition, accomplishing emergency repairs or moving to an alternate firing position. The number of rounds fired which trigger a movement to a full defilade is dependent on the type weapon system. The length of time spent in full defilade is dependent on the task being accomplished and the user specified times for the task.

#### Individual Firing of XML or DIVAD gun in Ground Support Role

The XML is allowed to fire two or three rounds from its firing defilade position. The determination of whether two or three rounds are fired is dependent on the sensing of the rounds and is best illustrated by table II. HIT refers to a sensed catastrophic kill and MISS refers to any other result.

The same logic as illustrated in table II applies to the DIVAD gun with 35 (or 40)mm gun. Note that each firing of the DIVAD gun represents a burst of 10 rounds.



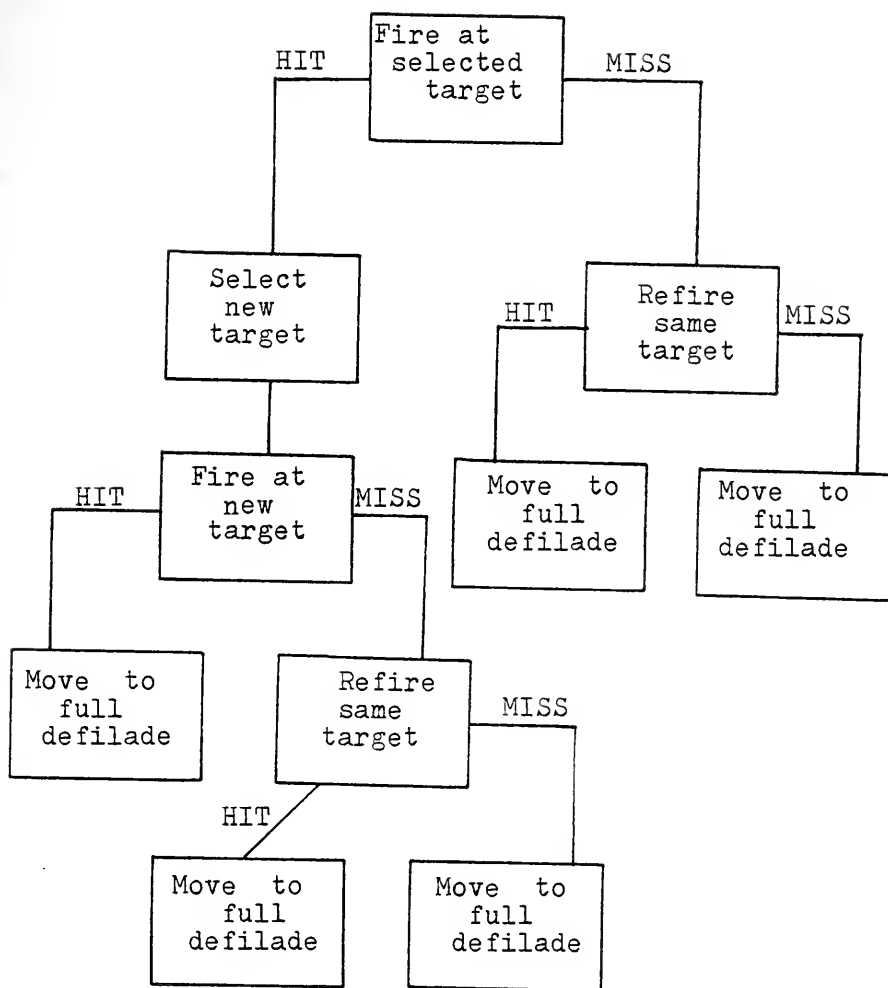


Table II Round Sensing



### Individual Firing of IFV,ITV, or DRAGON

The ITV, IFV, and DRAGON weapon systems go through the same sequence of turret defilade, firing defilade and full defilade as the XML and DIVAD. In the case of weapon systems which have no turret, the term turret defilade refers to the weapon system in a position of minimum exposure to direct fire while still allowing visual target acquisition. In the case of the ITV, IFV and DRAGON, the weapon system is allowed to fire two rounds regardless of sensing of round effect and is then moved to a full defilade position.

### Selection of Targets While in Firing Defilade

The STAR model differentiates between a ballistic round and a wire guided round in terms of the firing system's selection of subsequent targets while in firing defilade. The logic employed is such that a system firing a wire guided round will always go through the process of selecting a new target (which may result in the same target being re-engaged), while a system firing a ballistic projectile will continue to engage the same target (without going through the target selection process) until the target is sensed as a catastrophic kill (at which time a new target selection takes place). In all cases, a movement to full defilade causes the weapon system's list of detected targets to be set to zero. The subsequent return to turret defilade and then to firing defilade causes the normal detection and selection process to take place.



### Impact of ATGM (Anti-Tank Guided Missile) Rounds

The STAR model takes into account the eventuality of an ATGM round being fired and, before impact of the round, the firing system being destroyed. For both BLUE and RED missile firing systems which are killed with rounds in flight, the round is allowed to impact, but is always considered unguided at impact and assessed as a complete miss of the target.

### Tank Platoon Fire Control

BLUE tank platoon fire control is modeled under the assumption that platoon positions are well planned and prepared, sectors of fire assigned to individual tanks and strict fire control and fire discipline observed. Platoon fire control is modeled such that no two tanks in the same platoon are allowed to engage the same target, with one possible exception. If a tank searches its entire target list and finds that all of his detected targets are being engaged by members of his platoon, he will engage the highest priority target in his list regardless of whether or not that target is currently engaged by another platoon member.

### Mechanized Infantry Platoon Fire Control

BLUE mechanized infantry platoon fire control is modeled in a fashion similar to fire control for the tank platoon. No two IFVs within the same platoon are allowed to engage the same target simultaneously. The on board load of TOW rounds is assumed to be such that these rounds will be strictly controlled; thus, if all targets in a





selecting IFV's target list are engaged, that IFV will not fire until such time as he detects a target not engaged by another platoon member. The DRAGON teams in a mechanized infantry platoon are assumed to be employed independently and without advantage of communications with the platoon headquarters. Thus, DRAGON teams are allowed to detect, select, and fire on targets independent of the actions of other platoon members.

#### Selection Fire Control for ITVs

The ITV sections attached to the company team are assumed to operate under the same strict controls in regard to TOW ammunition as the IFVs in the mechanized infantry platoon. To model this, the ITVs in the company team are all filed in the same platoon set and fire control is modeled identically to that for the IFVs in the mechanized infantry platoon.

#### BLUE Company Fire Control

Fire control at the BLUE company team level is not as strictly modeled as are the fire control measures in the platoons. Company team fire control and distribution is accomplished by the careful selection of direction of movement (DIR.OF.MVMT) and primary direction of search (PRI.DIR) attributes for company team elements. These attributes, when properly designated, allow for overlapping and mutually supporting fields of fire for company team elements. No other allowance is made for elements to coordinate fires with weapon systems other than those in their assigned platoon.



## B. RED WEAPON SYSTEMS

### Terrain Utilization

Red weapon systems in the offense are assumed to move at a maximum speed allowed by the terrain and the enemy situation, while maintaining formation integrity as much as possible. Thus, the utilization of terrain by RED forces is primarily through the selection of the best attack routes to their assigned objectives. RED forces are assumed to fire on the move in the attack and are thus not afforded the option of seeking defilade while firing. The only exception is the case of the BMP while firing its ATGM. When firing a wire guided missile, BMPs stop to fire and seek the best cover and concealment along their movement route, while maintaining formation integrity to the extent possible.

### RED Tank Platoon Fire Control

The RED tanks in the simulation are assumed to mass fires on targets designated by the platoon leader. The RED tanks fire on the move and fire on the target designated by their platoon leader if the platoon leader is "alive", the platoon member has line of sight with the platoon leader and the platoon member has the proper type of ammunition available to engage the target. The failure to meet any of these criteria causes a RED tank to go through the selection and firing process independent of the leader's target. Upon impact of a round, the RED tank goes through the target selection process regardless of the sensing of the round.



Thus, RED tanks are not given the opportunity to sense the impact of a round and improve upon the hit probability of subsequent rounds fired at the same target. ZSUs in the ground support role use the same logic as RED tanks firing individually.

#### BMP Fire Control

Doctrinally, the overriding consideration of RED forces in the offense is the momentum of the attack. The primary role of the BMP is to serve as an infantry carrier. As a result, the BMP does not fire in the attack as long as the tanks of the unit to which it is attached provide protection for it. To model this tactic, the STAR model causes the BMP to select a target and check to see if any other weapon system in its company (to include other BMPs) is engaging that target; if so, the BMP does not fire at that particular target and selects another target from its list of currently detected targets. If every target in a BMP's list of detected targets is being engaged by other company members, the BMP continues to move without firing. The BMP stops to fire its ATGM but fires its 73mm gun on the move.

#### RED Company Fire Control

Fire control and distribution at the company level for RED forces is accomplished in the same manner as BLUE company level fire control.



#### IV. DETAILED EXPLANATION OF STAR

In this chapter each event and routine in STAR is explained in detail. With the exception of the PREAMBLE, the format used will include a description of the event or routine, including its purpose; a listing and definition of variables which are local to the event or routine; and a listing of the actual coding used in the current version of STAR, followed by a brief explanation of the code.

The PREAMBLE is somewhat different in structure and the primary area of interest is in the definition of the variables, arrays, entities, attributes, and sets which are global to all STAR events and routines.

##### A. PREAMBLE

###### General

The PREAMBLE is used to define global variables and arrays; declare entities, attributes, and sets; define events and FORTRAN routines; and prepare for subsequent statistical output. The PREAMBLE is similar to an extensive COMMON statement in the FORTRAN language in that everything declared in the PREAMBLE is essentially global, that is, defined for use throughout the program. This may be contrasted with variable and array definition in routines and events which insures that the variables and arrays so defined are local to the particular event or routine.





The PREAMBLE is also used to pack variables and arrays. Since extensive use of variable and array packing is used in STAR, this feature is discussed prior to the definition of the variables and arrays themselves. Two types of packing are utilized in STAR: field packing and bit packing.

Field packing is used to pack integer arrays such that each byte (8 bits) of an IBM 360-67 word (4 bytes or 32 bits) is used to represent an array location. Packing in this manner can reduce array core requirements to one quarter of their full word requirements. However, packing does limit the value that can be represented in an array location to  $2^{*8} - 1$  or 255. This maximum value is more than sufficient for the packed integer arrays used by STAR. The packed arrays can be identified in the PREAMBLE by a statement of the form: THE SYSTEM OWNS A TABLE(\* / 4). This is followed by a statement of the form: DEFINE TABLE AS A 2-DIMENSIONAL INTEGER ARRAY.

Bit packing is used to pack attributes of temporary entities. If desired, each bit of an IBM 360-67 word may be used to represent a variable. Again, the maximum value represented by a packed variable is  $2^{*B} - 1$ , where B is the number of bits used. For example, an entity might have the following packed attributes: A (NAME(1-5), AGE(6-12), ANNUAL.INCOME(13-31), SEX(32-32)). In this example, NAME may represent a maximum value of  $2^{*5} - 1$  or 31, AGE a value of 127, ANNUAL.INCOME a value of 524287, and SEX a value of 1.



Unless otherwise stated in the discussion that follows, all data values are initialized in the MAIN routine. Following this discussion a listing of the PREAMBLE coding is provided and a brief explanation is given for PREAMBLE lines which are not straightforward.

#### REAL Variables

X.STOP - The X coordinate on the battlefield used to stop RED forces from advancing.

Y.STOP - Similar to X.STOP except that it represents a Y coordinate on the battlefield.

R.PCT.ATT - A percent attrition for RED forces which is used to stop the simulation. If the RED forces reach or exceed this value, the simulation will halt.

B.PCT.ATT - The BLUE force percent attrition which used in a manner similar to R.PCT.ATT above.

DEF.TIME - The amount of time a TANK remains in full defilade following a firing sequence.

CONSTANT - The cosine of the TANK's search sector angle.

AREA - The TANK's search sector angle in degrees.

B.AREA - BLUE element analog of AREA.

R.AREA - RED element analog of AREA.

MMM - The time in seconds that it takes a TANK to detect a weapon system which is in the TANK's search sector and has fired on the TANK.

NNN - The time in seconds that it takes a TANK to detect a weapon system which is not in the TANK's search sector and has fired at the TANK.



DELTA.T - The time interval in seconds between successive detection scheduling events (event STEP.TIME).

PCT.VIS - The percentage of a target visible to the observer.

CRITICAL.VALUE - A number between 0 and 1 which is compared to the percentage of the target visible to the observer (PCT.VIS). Line of sight does not exist if PCT.VIS is less than CRITICAL.VALUE

W.K.C. - A range, in meters, which when added to the maximum effective range of a weapon, limits the maximum detection range to the sum of these two values.

#### INTEGER Variables

LIN - A variable used to count the number of calls to the line of sight routine.

RC.COUNT - The number of BLUE TANKs created; used as a reference value by RED TANKs.

BC.COUNT - The number of RED TANKs created; used as a reference value by BLUE TANKs.

TTT - A variable used to count the total number of rounds fired.

LINE.OF.SIGHT.EXISTS - A variable is assigned the value of 1 if PCT.VIS is greater than CRITICAL.VALUE, and 0 otherwise.

R.NUM.ALIVE - The starting number of RED weapon systems.

B.NUM.ALIVE - The starting number of BLUE weapon systems.

BLUE - A variable representing the color of friendly forces.



RED - A variable representing the color of opposing forces.

#### REAL Arrays

P.V - A single element array which, when returned as an argument from FORTRAN routine LOS, contains the value of PCT.VIS.

ZH - A single element array which, when returned as an argument from FORTRAN routine ELEV, contains the value of a TANK's Z coordinate (elevation).

#### INTEGER Arrays

BBBPOINT - An array containing the pointer values of all BLUE TANKs.

RRRPOINT - An array containing the pointer values of all RED TANKs.

TEMP.TGT - A holding array used to store pointer values from a TANK's list of detected targets.

LIST - An array containing the pointer values of a TANK's detected targets. Each TANK has a list which is accessed by referencing the pointer value of the LIST.

TARGET - A 2-dimensional array, each row of which contains the pointer value to a TANK's LIST and the pointer value of the TANK.

DS1 - The danger state array containing BLUE engagement priorities and preferred ammunition selections within rangebands.

DS2 - The danger state array containing RED engagement priorities and preferred ammunition selections within rangebands.





## ALPHA Arrays

QQ - An array used to store alphanumeric abbreviations for weapon types. This array is accessed when the results of an engagement are printed.

## System Owned Sets

TANKS - The set to which all weapon systems belong.

BLUE.ALIVE - The set to which all BLUE TANKs belong initially. BLUE TANKs are removed from this set as they are killed.

RED.ALIVE - The set to which all RED TANKs belong initially. RED TANKs are removed from this set as they are killed.

## Permanent Entities and Sets

COMPANY.COMMANDER - A permanent entity which is used solely as the owner of a company set, COMP.UNIT. This set contains all TANKs which are assigned to the same company.

PLATOON.LEADER - A permanent entity which is used solely as the owner of a platoon set, PLT.UNIT. This set contains all TANKs which are assigned to the same platoon.

## Temporary Entities and Attributes

The basic element in STAR is the temporary entity called TANK. Each TANK has a number of characteristics called attributes which are defined below. Those attributes, which must be input by the user, are discussed in the Input Requirements chapter of this thesis.

NAME - An integer variable whose value may not exceed 1023.



COLOR - An integer variable whose value is 1 if the color is BLUE, and 0 if the color is RED.

WPN.TYPE - An integer variable representing a particular type of weapon system (e.g., XM1, BMP, IFV, etc.). The value of WPN.TYPE may not exceed 31. In the current version of STAR only 9 types of weapons are played and are numbered sequentially from 1 to 9. For a list of weapon types, see input requirements chapter or table I.

VEH.TYPE - An integer variable representing a particular lethality configuration of a weapon system. Although not currently used in STAR, its value may not exceed 31.

ALIVE.DEAD - An integer variable with a value of 0 if the TANK is alive, and a value of 1 if the TANK is dead.

HIT.STATE - An alpha variable which contains an abbreviation of the TANK's status (e.g., DEAD, HIDE, etc.).

POINTER - An integer variable which contains the pointer value assigned to the TANK upon its creation.

X.CURRENT - A real variable representing the TANK's current X coordinate on the battlefield.

Y.CURRENT - A real variable representing the TANK's current Y coordinate on the battlefield.



Z.CURRENT - A real variable representing the TANK's current Z coordinate (elevation) in meters on the battlefield.

SPD - A real variable representing the TANK's current speed in meters per second.

T.SPD - A real variable representing the simulated battle time at which a TANK's speed was last set.

DIR.OF.MVMT - A real variable representing the direction of movement of the TANK. This value is entered in mils and converted to radians in the program.

PRI.DIR - A real variable representing the primary direction of search for a TANK. This value is entered in mils and converted to radians in the program.

DEFNUM - An integer variable representing the current defilade condition of the TANK. This attribute is assigned the following values: 1 - full defilade, 2 - turret defilade, 3 - firing defilade, 4 - seeking concealment while stopping to fire, 5 - defilade condition determined by the terrain model.

AP.TOW - An integer variable representing the number of rounds of ammunition type 1 which are currently on board the TANK. For XM1s and T72s, this represents armor piercing



ammunition. For IFVs, ITVs, and BMPs, this represents anti-tank guided missiles.

HE.DRAG - An integer variable representing the number of rounds of ammunition type 2 which are currently on board the TANK. For XMLs and T72s, this represents high explosive anti-tank ammunition. For DRAGONS this represents a short range anti-tank missile.

AW1.OR.MSL3 - An integer variable representing the number of rounds of ammunition type 3 which are currently on board the TANK. For XMLs this represents .50 caliber ammunition counted in 10 round bursts. For T72s this represents 12.7mm machinegun ammunition counted in 10 round bursts. For BMPs this represents 73mm high explosive ammunition. For IFVs this represents 25mm Bushmaster ammunition counted in 10 round bursts. For DIVADs and ZSUs this represents their basic air defense ammunition counted in 10 round bursts.

AW2.OR.ADM - An integer variable representing the number of rounds of ammunition type 4 which are currently on board the TANK. The current version of STAR does not use this attribute, but it is provided for the user.





HITSHOT - An integer variable representing the number of hits (catastrophic kills) scored by a TANK during its current firing sequence.

MISSSHOT - An integer variable representing the number of misses (anything other than a catastrophic kill) scored by a TANK during its current firing sequence.

PROJ0 - An integer variable representing the type of ammunition currently selected by the TANK.

OP.RNG - An integer variable representing the maximum range at which a TANK will attempt to engage another TANK.

MZL.VEL - An integer variable representing the velocity of the currently selected ammunition type (PROJ0).

M1, M2, M3, M4 - Integer variables representing the velocities associated with each of the 4 ammunition types.

ND.HIT - An integer variable representing the number of hits sustained by a TANK which have caused no damage.

M.HIT - An integer variable representing the number of hits sustained by a TANK which have caused mobility damage.

F.HIT - An integer variable representing the number of hits sustained by a TANK which have caused firepower damage.

MF.HIT - An integer variable representing the number of hits sustained by a TANK which caused simultaneous mobility and firepower damage.



K.HIT - An integer variable representing the number of hits sustained by a TANK which were sufficient to cause a catastrophic kill (K-kill).

NUM.HIT - An integer variable representing the total number of hits, including no damage hits, sustained by a TANK.

FIRE.AT - An integer variable representing the total number of rounds fired at a TANK.

SEC, PLT, CO, BN, RGT, BDE, DIV - Integer variables representing the identification number of the section, platoon, company, battalion, regiment, brigade, and division to which the TANK is assigned.

FIP - An integer variable which is assigned the value 1 if a TANK has a firing in progress, and a 0 otherwise.

SCHED - An integer variable which is assigned the value 1 if a TANK has a fire event scheduled, and a 0 otherwise.

SECOND.SHOT - An integer variable which is assigned the value 1 if the TANK is firing a second round on the same target.

PH - A real variable representing the probability of hit as determined by routine COMPUTE.



FOE - An integer variable representing the pointer value of the TANK's current target.

CHECK.TIME - A real variable representing the time at which a TANK's next fire event is to occur.

RANGE - A real variable representing the range in meters to a TANK's current target.

STEPS - An integer variable representing the number of STEP.TIME events scheduled for the TANK.

C.1, C.2, ~~C.3~~ C.3, C.4 - Integer variables representing the amount of ammunition loaded in each of five user defined compartments on a TANK. These attributes are not used in the current version of STAR, but are provided for use with vulnerability packages which are functions of ammunition storage location.

PLOW.COND - An integer variable representing the availability of a mineplow on a TANK. The following codes are used: 0 = no plow available, 1 - plow available but not in use, 2 - plow being used.

DUMMY - An integer variable which may take on values 0 or 1. This variable is not currently used in STAR.

MKILL - An integer variable assigned the value 1 if a mobility kill is sustained by a TANK.



FKILL - An integer variable assigned the value 1 if a firepower kill is sustained by a TANK.

MFKILL - An integer variable assigned the value 1 if a mobility and firepower kill is sustained by a TANK.

KKILL - An integer variable which is assigned a value 1 if the TANK has been catastrophically killed.

COCODR, PLTLDR, SECLDR - Integer variables representing the names of a TANK's company commander, platoon leader, and section leader respectively.

X.L, Y.L - Real variables which form a vector representing the left sector limit line of a TANK's search sector.

X.R, Y.R - Real variables which form a vector representing the right sector limit line of a TANK's search sector.

M.D - A real variable representing the accumulated percentage of mobility damage sustained by a TANK.

F.D - A real variable representing the accumulated percentage of firepower damage sustained by a TANK.

HTO - A real variable representing the height of the observer, in meters, above macro terrain.





HTTGT - A real variable representing the height of the target, in meters, above macro terrain.

### Events

LOC.UPD - This event is used to periodically update the X, Y, and Z coordinates of TANKs on the battlefield. The pointer value of the TANK being updated is required as an argument.

STEP.TIME - This event is used to schedule detection events. The pointer value of a BLUE TANK is required as an argument.

DETECT - This event processes the detections scheduled by event STEP.TIME. The pointer values of the observer and the detected TANK are required as arguments.

TARGET.SELECT - This event uses danger state arrays, a TANK's list of detected targets, and tactical fire control modules to select targets and schedule FIRE events. The pointer value of the selecting TANK is required as an argument.

FIRE - This event simulates a TANK firing on its target. The pointer value of the firer and the target are required as arguments.



IMPACT - This event simulates the consequence of a FIRE event. The pointer values of the firer and the target are required as arguments.

FINAL.DEATH - This event changes the status of a TANK from alive to dead after an appropriate period of time. The pointer value of the TANK to be killed is required as an argument.

HIDE - This event changes the defilade condition (DEFNUM) of a TANK at ~~the~~ appropriate time. The pointer value of the TANK and the type of defilade change are required arguments.

ATTRITION.CHECK - This event periodically checks the total losses by RED and BLUE forces and schedules a halt to the simulation if required.

STOP.SIMULATION - This event prints final output and brings execution of STAR to a halt.

#### FORTTRAN Routines

SETUP - This routine reads initial values for terrain features which represent the battlefield.

ELEV - This routine calculates the Z coordinate (elevation) for a TANK at a given location on the battlefield. ELEV requires three arguments: the X coordinate



of the TANK, the Y coordinate of the TANK, and the single element array ZH, whose value upon return from ELEV is the Z coordinate of the TANK.

LOS - This routine calculates the percentage of the target visible to the observer. LOS requires 9 arguments: the X, Y, and Z coordinates of the observer and target, the heights of the observer and target, and the single element array P.V, whose value upon return from LOS will be the percentage of the target visible to the observer.

#### Coding and Brief Explanation

The coding for the PREAMBLE is shown below, followed by a brief explanation:

```
1  PREAMBLE

2  DEFINE X.STOP,Y.STOP,PCT.ATT,B.PCT.ATT,DEF.TIME,
CONSTANT,AREA,

3      HALT.TIME,MMM,DELTA.T,NNN,B.AREA,R.AREA,CRITICAL.
VALUE,

4      PCT.VIS,AND W.K.C AS REAL VARIABLES

5      DEFINE LIN,RC.COUNT,BC.COUNT,TTT,LINE.OF.SIGHT.
EXISTS,R.NUM.ALIVE,

6      B.NUM.ALIVE,BLUE,AND RED AS INTEGER VARIABLES
```



```
7  DEFINE QQ AS A 1-DIMENSIONAL ALPHA ARRAY
8  DEFINE P.V AS A REAL,1-DIMENSIONAL ARRAY
9  DEFINE ZH AS A REAL, 1-DIMENSIONAL ARRAY
10 DEFINE BBBPOINT AS AN INTEGER 1-DIMENSIONAL ARRAY
11 DEFINE RRRPOINT AS AN INTEGER 1-DIMENSIONAL ARRAY
12     DEFINE TEMP.TGT AS AN INTEGER, 1-DIMENSIONAL ARRAY
13     DEFINE TARGET AS AN INTEGER, 2-DIMENSIONAL ARRAY
14     DEFINE LIST AS AN INTEGER, 1-DIMENSIONAL ARRAY
15     DEFINE BLUE.PTTO MEAN 1
16     DEFINE RED TO MEAN 0
17 THE SYSTEM OWNS A TANKS
18 THE SYSTEM OWNS A BLUE.ALIVE AND A RED.ALIVE
19 THE SYSTEM HAS A DS1(* /4)
20 DEFINE DS1 AS A 2-DIMENSIONAL INTEGER ARRAY
21 THE SYSTEM HAS A DS2(* /4)
22 DEFINE DS2 AS A 2-DIMENSIONAL INTEGER ARRAY
23 GENERATE LIST ROUTINES
24 PERMANENT ENTITIES
25 EVERY COMPANY.COMMANDER OWNS A COMP.UNIT
26 EVERY PLATOON.LEADER OWNS A PLT.UNIT
27     TEMPORARY ENTITIES
```





28 EVERY TANK HAS A (NAME(1-10),COLOR(11-11),WPN.TYPE  
 (12-16),VEH.TYPE(17-21),  
 29 ALIVE.DEAD(22-32)),A HIT.STATE, A POINTER, A X.CURRENT,  
 A Y.CURRENT,  
 30 A Z.CURRENT, A SPD, A T.SPD, A DIR.OF.MVMT, A PRI.  
 DIR, A (DEFNUM(1-8),  
 31 AP.TOW(9-14),HE.DRAG(15-20),AW1.OR.MSL3(21-26),AW2.  
 OR.ADM(27-32)),  
 32 A (HITSHOT(1-2),MISSSHOT(3-4),PROJO(5-7),OP.RNG(8-19),  
 MZL.VEL(20-31)),  
 33 A (M1(1-16),M2(17-32),A (M3(1-16),M4(17-32)),A  
 (ND.HIT(1-4),N.HIT(5-8),  
 34 F.HIT(9-12),MF.HIT(13-16),K.HIT(17-20),NUM.HIT(21-26),  
 FIRED.AT(27-32)),  
 35 A (SEC(1-11),PLT(12-22),CO(23-32)), A (BN(1-7),  
 RGT(8-15),BDE(16-18),DIV(19-21),  
 36 FIP(22-22),SCHED(23-23),SECOND.SHOT(24-25)),A PH, A  
 FOE, A CHECK.TIME, A RANGE,  
 37 A (STEPS(1-2), C.1(3-8),C.2(9-15),C.3(16-21),C.4  
 (22-27),PLOW.COND(28-32)),  
 38 A (DUMMY(1-1),MKILL(2-11),FKILL(12-21),MFKILL(22-31),  
 KKILL(32-32)),



39 A COCDR, A PLTLDR, A SECLDR, A X.L, A Y.L, A X.R,  
 A Y.R, A M.D, A F.D, A HTO,  
 40 A HTTG, AND MAY BELONG TO A TANKS, A PLT.UNIT, A  
 COMP.UNIT, A RED.ALIVE,  
 41 AND A BLUE.ALIVE  
 42 DEFINE C.1,C.2,C.3,C.4,DEFNUM,NAME,COLOR,WPN. TYPE,  
 ALIVE.DEAD,FIP,SCHED,STEPS,  
 43 SECOND.SHOT,SEC,PLT,CO,BN,RGT,BDE,DIV,POINTER,  
 FOE,COCDR,PLTLDR,SECLDR,  
 44 ND.HIT,M.HIT,F.HIT,MF.HIT,K.HIT,NUM.HIT,FIRE.  
 AT,AP.TOW,HE.DRAG,  
 45 AW1.OR.MSL3,AW2.OR.ADM,M1,M2,M3,M4,VEH,TYPE,  
 MISSSHOT,HITSHOT,PROJO.  
 46 OP.RNG,MKILL,FKILL,MFKILL,KKILL,PLOW.COND,  
 MZL.VEL, AND DUMMY AS  
 47 INTEGER VARIABLES  
 48 DEFINE HIT.STATE AS AN ALPHA VARIABLE  
 49 EVENT NOTICES INCLUDE STOP.SIMULATION AND ATTRITION.  
 CHECK  
 50 EVERY HIDE HAS A COVER AND A CODE  
 51 EVERY FINAL.DEATH HAS A PURPOSE  
 52 EVERY LOC.UPDATE HAS A VEHICLE



```

53      EVERY STEP.TIME HAS A ENTIRE.TANK

54      EVERY DETECT HAS A WHOLE.TANK AND A DET.FOE.

ENTIRE.TANK

55      EVERY TARGET.SELECT HAS A FIRING.TANK

56      EVERY FIRE HAS A SHOOTING.TANK AND A CORE.POINTER.

OR.TGT.ID

57      EVERY IMPACT HAS A TANK.THAT.SHOT AND A BLOCK.

POINTER.OR.TGT.ID

58  DEFINE LOS AS A FORTRAN ROUTINE GIVEN 9 ARGUMENTS

59  DEFINE ELEV AS A FORTRAN ROUTINE GIVEN 3 ARGUMENTS

60  DEFINE SETUP AS A FORTRAN ROUTINE GIVEN 0 ARGUMENTS

61  TALLY LIN AS THE NUMBER OF          PCT.VIS

62  END

```

Lines 15-16 allow the use of the words BLUE and RED throughout the program when referring to a TANK's color.

Lines 17-18 define sets owned by the system, as opposed to those owned by entities.

Lines 19 and 21 declare DS1 and DS2 as packed integer arrays.

Line 23 informs the system that the list routine option is desired. This option allows the user to print all arrays and contents of sets using simplified commands.



Line 25 establishes set ownership of the company sets by permanent entities called COMPANY.COMMANDERS.

Lines 40-41 allow the temporary entities, TANKs, to belong to a variety of sets.

Line 61 establishes a SIMSCRIPT statistical routine which counts the number of times that the line of sight routine is called.

## B. MAIN PROGRAM

### Description

The MAIN program of the STAR model prepares the model for execution. The arrays that were defined in the PREAMBLE are dimensioned to the appropriate size by the use of the RESERVE statement. The MAIN program calls the FORTRAN routine SETUP which prepares the appropriate data for the FORTRAN routines LOS and ELEV. The MAIN program sets the initial values of the variables globally defined in the PREAMBLE by use of the LET or READ statement.

A major function of the MAIN program is to create the entities, sets, and attributes defined in the PREAMBLE. Two separate DO LOOPS exist in the STAR MAIN program for creation of entities. The first creates every BLUE weapon system





to be simulated, reads or sets the initial values of the weapon system attributes and files the entity created in the appropriate sets. The second DO LOOP performs the same function for RED weapon systems in the simulation.

The final function of the MAIN program is to schedule those events which must be executed immediately upon start of the simulation.

### Local Variables

The following are local variables of the MAIN program:

I - An integer variable used as a counter in the DO LOOPS which create the entities of the simulation, and as a counter in the loop which sets the initial values in the random number streams used in the simulation.

J - An integer variable used as a counter in the loop which sets the initial values in the random number streams used in the simulation.

PNUM - An integer variable read by the MAIN program which indicates the number of platoon sets (PLT.UNIT) to be created.

CNUM - An integer variable read by the MAIN program which indicates the number of company sets (COMP.UNIT) to be created.



The coding for the MAIN program is shown below, followed by a brief explanation:

```
1  MAIN
2  DEFINE I,J,PNUM,AND CNUM AS INTEGER VARIABLES
3  RESERVE DS1(*,*) AS 15 BY 24
4  RESERVE P.V(*) AS 1
5  RESERVE ZH(*) AS 1
6  RESERVE DS2(*,*) as 9 BY 40
7  RESERVE TARGET(*,*) AS 250 BY 2
8  RESERVE TEMP.TGT(*) AS 150
9  RESERVE QQ(*) AS 9
10 LET QQ(1)= "XM1"
11 LET QQ(2)= "XM1"
12 LET QQ(3)= "IFV"
13 LET QQ(4)= "ITV"
14 LET QQ(5)="DVAD"
15 LET QQ(6)="DRAG"
16 LET QQ(7)="T72"
17 LET QQ(8)="BMP"
18 LET QQ(9)="ZSU"
19 CALL SETUP
20 READ R.NUM.ALIVE, B.NUM.ALIVE, DELTA.T
```



```

21 READ PNUM, CNUM
22 LET N.PLATOON.LEADER = PNUM
23 LET N.COMPANY.COMMANDER = CNUM
24 CREATE EVERY PLATOON.LEADER
25 CREATE EVERY COMPANY.COMMANDER
26 READ X.STOP, Y.STOP, R.PCT.ATT, B.PCT.ATT
27 READ DS1
28 READ DS2
29 RESERVE BBBPOINT(*) AS R.NUM.ALIVE
30 RESERVE RRRPOINT(*) AS B.NUM.ALIVE
31 LET LINES.V=70
32 LET DEF.TIME = 20.0
33 LET CRITICAL.VALUE = .2
34 LET B.AREA=90.
35 LET R.AREA=90.0
36 LET AREA = B.AREA
37 LET CONSTANT = COS.F((AREA/360.0)* 2.0 * PI.C)
38 LET W.K.C = 250
39 LET NNN=2.
40 LET LIN=0
41 LET MMM=6.
42 LET RC.COUNT = 0

```



```

43 LET BC.COUNT = 0
44 LET TTT = 1
45 FOR I = 1 TO B.NUM.ALIVE, DO
46 LET RC.COUNT = RC.COUNT + 1
47 CREATE A TANK
48 READ NAME(TANK), COLOR(TANK), WPN.TYPE(TANK), VEH.
TYPE(TANK), AP.TOW(TANK),
49 HE.DRAG(TANK), AW1.OR.MSL3(TANK), AW2.OR.ADM(TANK),
SEC(TANK), PLT(TANK),
50 CO(TANK), BN(TANK), RGT(TANK), BDE(TANK), DIV(TANK),
X.CURRENT(TANK),
51 Y.CURRENT(TANK), SPD(TANK), DIR.OF.MVMT(TANK), PRI.
DIR(TANK), MI(TANK),
52 M2(TANK), M3(TANK), M4(TANK), COCDR(TANK), PLTLDR(TANK),
SECLDR(TANK)
53 , OP.RNG(TANK)
54 LET DEFNUM(TANK) = 2
55 RESERVE LIST(*) AS 1
56 LET LIST(1) = 0
57 LET HTO(TANK) = 3.0
58 LET HTTGT(TANK) = 3.0
59 LET POINTER(TANK) = TANK

```





```

60 LET RRRPOINT(I) = TANK
61 LET TARGET(I,1) = LIST(*)
62 LET LIST(*) = 0
63 LET TARGET(I,2) = TANK
64 LET DIR.OF.MVMT(TANK) = DIR.OF.MVMT(TANK) * 2 * PI.
C/6400.0
65 LET PRI.DIR(TANK)=PRI.DIR(TANK)*2*PI.C/6400.0
66 LET COCDR(TANK) = RRRPOINT(COCDR(TANK))
67 LET PLTLDR(TANK) = RRRPOINT(PLTLDR(TANK))
68 LET SECLDR(TANK) = RRRPOINT(SECLDR(TANK))
69 FILE TANK IN TANKS
70 FILE TANK IN BLUE.ALIVE
71 FILE TANK IN PLT.UNIT(PLT(TANK))
72 FILE TANK IN COMP.UNIT(CO(TANK))
73 LOOP
74 FOR I = B.NUM.ALIVE+1 TO B.NUM.ALIVE+R.NUM.ALIVE, DO
75 LET BC.COUNT = BC.COUNT + 1
76 CREATE A TANK
77 READ NAME(TANK), COLOR(TANK), WPN.TYPE(TANK), VEH.
TYPE(TANK), AP.TOW(TANK),
78 HE.DRAG(TANK), AW1.OR.MSL3(TANK), AW2.OR.ADM(TANK),
SEC(TANK), PLT(TANK),

```



```

79 CO(TANK), BN(TANK), RGT(TANK), BDE(TANK), DIV(TANK),
X.CURRENT(TANK),

80 Y.CURRENT(TANK), SPD(TANK), DIR.OF.MVMT(TANK), PRI.
DIR(TANK), M1(TANK),

81 M2(TANK), M3(TANK), M4(TANK), COCDR(TANK), PLTLDR(TANK),
SECLDR(TANK)

82 , OP.RNG(TANK)

83 LET DEFNUM(TANK) = 5

84 RESERVE LIST(*) AS 1

85 LET LIST(1) = 0

86 LET HTO(TANK) = 3.0

87 LET HTTGT(TANK) = 3.0

88 LET POINTER(TANK) = TANK

89 LET BBBPOINT(I-B.NUM.ALIVE) = TANK

90 LET TARGET(I,1) = LIST(*)

91 LET LIST(*) = 0

92 LET TARGET(I,2) = TANK

93 LET SPD(TANK) = 5.0

94 LET DIR.OF.MVMT(TANK) = DIR.OF.MVMT(TANK) * 2 * PI.
C/6400.0

95 LET PRI.DIR(TANK)=PRI.DIR(TANK)*2*PI.C/6400.0

96 LET COCDR(TANK)=BBBPOINT(COCDR(TANK)-B.NUM.ALIVE)

```



```

97 LET PLTLDR(TANK)=BBBPOINT(PLTLDR(TANK)-B.NUM.ALIVE)
98 FILE TANK IN TANKS
99 FILE TANK IN RED.ALIVE
100 FILE TANK IN PLT.UNIT(PLT(TANK))
101 FILE TANK IN COMP.UNIT(CO(TANK))
102 LOOP
103 FOR EACH TANK IN BLUE.ALIVE, DO
104 CALL ELEV GIVEN X.CURRENT(TANK), Y.CURRENT(TANK),
ZH(*)
105 IF ZH(1) LE 250.0 LET ZH(1) = 250.0 ALWAYS LET
Z.CURRENT(TANK) = ZH(1)
106 LOOP
107 FOR I = 1 TO 9, FOR J = 1 TO 10, LET XX=UNIFORM.
F(0.,1.,I)
108 FOR EACH TANK IN TANKS LET PRI.DIR(TANK) = PRI.DIR
(TANK) + DIR.OF.MVMT(TANK)
109 FOR EACH TANK IN TANKS CALL SET.SECTOR(TANK)
110 FOR EACH TANK IN RED.ALIVE SCHEDULE A LOC.UPDATE
(TANK) NOW
111 FOR EACH TANK IN BLUE.ALIVE LET STEPS(TANK) = 1
112 PRINT 1 LINE THUS
RND FIR TYPE AM TGT TYPE TIME.V STAT RANGE X-FIR Y-FIR X-TGT
Y-TGT

```



```
113  FOR EACH TANK IN BLUE.ALIVE SCHEDULE A STEP.TIME(TANK)
NOW
114  SCHEDULE AN ATTRITION.CHECK IN 10.0 * DELTA.T UNITS
115      START SIMULATION
116  STOP
117  END
```

Lines 1-2 define the MAIN program and local variables.

Lines 3-8 dimension the numeric arrays defined in the  
PREAMBLE.

Lines 9-18 dimension the alphanumeric array QQ and place  
the appropriate alphanumeric characters in the array  
locations.

Line 19 calls the FORTRAN routine SETUP.

Line 20 reads the initial number of RED and BLUE systems  
in the simulation and the time increment for the simulation.

Line 21 reads the number of platoon and company sets  
to be created.

Lines 22-25 create the platoon leader and company commander  
entities and simultaneously create subscripted company and  
platoon sets.





Line 26 reads the X and Y coordinates used for stopping criteria, and reads the percent attrition for BLUE and RED systems to be used as a stopping criteria.

Lines 27-28 read in values of the danger state arrays.

Lines 29-30 dimension the arrays BBBPOINT and RRRPOINT.

Lines 31-44 set initial values for PREAMBLE defined global variables.

Lines 45-53 create each entity representing the BLUE weapon systems and read in initial attribute values.

Lines 54-63 set initial attribute values of the entities created, initialize the target list for each entity created (LIST) and place the appropriate pointer values in the array TARGET.

Lines 64-65 convert the value of PRI.DIR and DIR.OF.MVMT attributes from mils to radians

Lines 66-68 convert the attributes COCDR, PLTLDR, and SECLDR (which were read in as vehicle numbers) to the proper pointer value of the entity's company commander, platoon leader and section leader.

Lines 69-73 place the entity created in the appropriate sets and loop back to line 45.



Lines 74-82 create each entity representing RED weapon systems, and read in the initial attribute values.

Lines 83-93 set initial values of the attributes of the entities created, initialize the target list for each entity (LIST) and place the appropriate pointer values in the array TARGET.

Lines 94-95 convert the PRI.DIR and DIR.OF.MVMT attributes to radians.

Lines 96-97 convert the COCDR, and PLTLDR attributes to the proper pointer value of the entity's platoon leader or company commander.

Lines 98-102 file the entity in the proper sets and loop back to line 74.

Lines 103-106 set initial elevation for the BLUE elements by calling the FORTRAN routine ELEV.

Line 107 sets the starting values in each of the random number streams used in the simulation.

Line 108 sets the PRI.DIR attribute of each entity to the form used in routine SET.SECTOR.

Line 109 calls routine SET.SECTOR for every entity, which sets the limits of the entity's search sector.



Line 110 schedules event LOC.UPDATE to occur for every RED weapon system immediately upon start of the simulation.

Line 111 sets the STEPS attribute for each BLUE entity.

Line 112 prints the column headings for printed output.

Line 113 schedules event STEP.TIME to occur for every BLUE weapon system immediately upon start of the simulation.

Line 114 schedules event ATTRITION.CHECK to occur at a time ten times DELTA.T into the simulation.

Line 115 starts the simulation.

Lines 116-117 are the required MAIN program control statements.

#### C. EVENT LOC.UPDATE

##### Description

Event LOC.UPDATE is called every DELTA.T units by the system timer and is used to update the X, Y, and Z coordinates of each RED TANK that is currently alive. This event insures that all positions have been updated prior to the execution of event STEP.TIME.

##### Local Variable

The following is a local variable of this routine:



TANK - An integer variable containing the pointer value of the weapon system for which a location update is required.

### Coding and Brief Explanation

The coding for event LOC.UPDATE is shown below, followed by a brief explanation:

```
1  UPON LOC.UPDATE(TANK)
2  DEFINE TANK AS AN INTEGER VARIABLE
3  IF ALIVE.DEAD(TANK) EQ 1 RETURN ELSE
4  CALL LOC(TANK)
5  SCHEDULE A LOC.UPDATE(TANK) IN DELTA.T UNITS
6  RETURN END
```

Lines 1-2 define the event and local variable.

Line 3 tests the ALIVE.DEAD attribute of the TANK to prevent dead TANKs from having their locations updated.

Line 4 calls routine LOC which calculates new X, Y, and Z coordinates for the TANK.

Lines 5-6 reschedule another LOC.UPDATE for this TANK in DELTA.T units (currently 30 seconds). Control is then returned to the system timer.





#### D. EVENT STEP.TIME

##### Description

Event STEP.TIME is used by STAR to generate detections of battlefield elements by one another. STEP.TIME is scheduled to occur every DELTA.T units (currently 30 seconds) and affects all TANKs which are alive at the beginning of the time period. Prior to STEP.TIME, each TANK's X, Y, and Z coordinates are updated by event LOC.UPDATE.

Each BLUE TANK that enters event STEP.TIME has the opportunity to schedule a detection on a RED TANK. Likewise, each RED TANK has the opportunity to schedule a detection on the BLUE TANK that generated the STEP.TIME event. Detection times are generated by routine CARDIO which is discussed in a subsequent section.

Range, sector, and time filters are used by event STEP.TIME to prevent unnecessary line of sight calls. Although the current line of sight algorithm (FORTRAN routine LOS) is very efficient, it still requires many calculations. Consequently, the filters mentioned above and described in the coding section below are important in reducing execution time.



## Local Variables

The following are local variables of this event:

A - An integer variable containing the pointer value of the BLUE TANK which generated the current STEP.TIME event.

Note that the global variable TANK represents RED TANKs in this event.

ANSWER - An integer variable which is assigned a value of 1 if a target is in the observer's search sector, and 0 otherwise.

LOSE - An integer variable which is assigned a value of 1 if line of sight exists between two elements, and 0 otherwise.

R - A real variable representing the range in meters between two TANKs.

RN.B - A real variable assigned a random value from a Uniform (0,1) probability distribution. This value is passed as an argument to routine CARDIO.

RN.R - A real variable with the same characteristics as RN.R.

BDET.TIME - A real variable, which when returned from routine CARDIO, represents the time required to detect a RED TANK by a BLUE TANK.



RDET.TIME - Similar to BDET.TIME except that it is used for RED TANKs detecting BLUE TANKs.

### Coding and Brief Explanation

The coding for event STEP.TIME is shown below, followed by a brief explanation:

```
1  UPON STEP.TIME(A)
  1/
2  DEFINE ANSWER AS AN INTEGER VARIABLE
3  DEFINE RN.B, RN.R, AND R AS REAL VARIABLES
4  DEFINE LOSE AND A AS INTEGER VARIABLES
5  DEFINE RDET.TIME AND BDET.TIME AS REAL VARIABLES
6  LET STEPS(A)=STEPS(A)-1
7  LET BDET.TIME=99  LET RDET.TIME = 99  ✓
8  IF ALIVE.DEAD(A) EQ 1 RETURN ELSE
9  IF TIME.V GE 2.0 * DELTA.T
10 LET LIST(*) = TARGET(NAME(A),1)
11 IF DEFNUM(A) EQ 1 RELEASE LIST(*)  RESERVE LIST(*)
AS 1
12 LET TARGET(NAME(A),1) = LIST(1)=0  LET LIST(*) = 0
GO TO NORMAL
13     ELSE
14 IF LIST(1) = 0
15 CALL CHG.SEC.SEARCH(A)
```



```

16  ALWAYS
17  LET LIST(*)=0
18  REGARDLESS
19  'NORMAL'
20  FOR EACH TANK IN RED.ALIVE, DO
21  IF W.BLUE.ALIVE EQ A AND TIME.V GE 2.0 * DELTA.T
22  LET LIST(*) = TARGET(NAME(TANK),1)
23  IF LIST(1) = 0
24  CALL CHG.SEC.SEARCH(TANK)
25  ALWAYS
26  LET LIST(*)=0
27  ALWAYS
28  LET RN.B= UNIFORM.F(0.,1.,7)
29  LET RN.R= UNIFORM.F(0.,1.,7)
30  IF (Y.CURRENT(TANK) + X.CURRENT(TANK)/2.0) LE 8000.0
31  LET ALIVE.DEAD(TANK) = 1 REMOVE TANK FROM RED.ALIVE
GO TO LOOP ELSE
32  CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT(TANK),
Y.CURRENT(TANK)) YIELDING R
33  IF OP.RNG(A) + W.K.C. GT R CALL SECTOR.CHECK(A,TANK)
YIELDING ANSWER

```





```

34      IF ANSWER EQ 1 CALL CARDIO(A,TANK,R,1.0,RN.B)
YIELDING BDET.TIME

35      ELSE ALWAYS

36      ALWAYS

37      IF OP.RNG(TANK) + W.K.C. GT R CALL SECTOR.CHECK(TANK,
A) YIELDING ANSWER

38      IF ANSWER EQ 1 CALL CARDIO(TANK,A,R,1.0,RN.R)
YIELDING RDET.TIME

39      ELSE ALWAYS

40      ALWAYS

41      IF BDET.TIME LT DELTA.T OR RDET.TIME LT DELTA.T

42      CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT
(A),HTO(A),X.CURRENT(TANK),

43      Y.CURRENT(TANK),Z.CURRENT(TANK),HTTGT(TANK),P.V(*)

44      LET PCT.VIS=P.V(1)

45      IF PCT.VIS GT CRITICAL.VALUE LET LOSE=1 JUMP AHEAD
ELSE LET LOSE=0 HERE

46      'SCHEDULE' IF LOSE EQ 1 AND BDET.TIME LT DELTA.T

47      CALL CARDIO(A,TANK,R,PCT.VIS,RN.B) YIELDING BDET.TIME

48      IF BDET.TIME GT DELTA.T JUMP AHEAD ELSE

49      SCHEDULE A DETECT(A,TANK) IN BDET.TIME UNITS

50      HERE

```



```

51  REGARDLESS
52  IF LOSE EQ 1 AND RDET.TIME LT DELTA.T
53  CALL CARDIO(TANK,A,R,PCT.VIS,RN.R) YIELDING RDET.TIME
54  IF RDET.TIME GT DELTA.T JUMP AHEAD ELSE
55  SCHEDULE A DETECT(TANK,A) IN RDET.TIME UNITS
56  HERE
57  REGARDLESS
58  ALWAYS  'LOOP' LOOP
59  IF STEPS(A) GE 2 RETURN
60  ELSE SCHEDULE A STEP.TIME(A) IN DELTA.T UNITS LET
STEPS(A)=STEPS(A)+1 RETURN END

```

Lines 1-5 define the event and local variables.

Line 6 decrements the steps attribute for the BLUE TANK that generated the current STEP.TIME.

Line 7 assigns default values to BDET.TIME and RDET.TIME.

Line 8 insures that the BLUE TANK is still alive prior to proceeding.

Lines 9-19 perform several tests after simulated time has reached 60 seconds. If a BLUE TANK is in full defilade, his detected list is purged. This simulates the loss of information which accompanies being in a position from which line of sight does not exist. If the BLUE TANK is not in



full defilade, but his detected list is empty, his sector of search is changed in attempt to acquire new targets in a different search area. BLUE TANKs then attempt to schedule DETECT events in the usual manner.

Line 20 effects sequential access to the RED TANKs which are still alive.

Lines 21-27 change the search sector for those RED TANKs whose detected lists are empty. Note that this is accomplished only when the first BLUE TANK accesses the set of RED TANKs.

Lines 28-29 draw random numbers for use by routine CARDIO.

Lines 30-31 prevent RED TANKs from moving off the map. By setting the ALIVE.DEAD attribute to 1 when a RED TANK reaches the stopping point, the simulation is prevented from executing indefinitely since the RED attrition percentage will eventually reach 100 percent.

Line 32 calculates the current range between two TANKs.

Lines 33-36 insure for BLUE TANKs that a potential detected target is within range and within sector. If this is the case, routine CARDIO is called with 100 percent visibility assumed. This generates a best case detection time.



Lines 37-40 perform the above tests for RED TANKs detecting BLUE TANKs.

Lines 41-45 call FORTRAN routine LOS if either potential detect time calculated above was less than DELTA.T seconds. Line of sight exists if the percentage of the target visible to the observer is greater than a user defined value (currently .2).

Line 46 insures that line of sight exists between the BLUE observer and the RED target, and that the potential detection time is less than DELTA.T seconds prior to calling routine CARDIO again.

Line 47 calls routine CARDIO and returns with a detection time for BLUE detecting RED.

Lines 48-50 schedule a detection in the amount of time returned by routine CARDIO if this time is less than DELTA.T seconds.

Lines 51-57 are similar to lines 46-50 except that they apply to RED TANKs observing BLUE TANKs.

Lines 59-60 schedule another STEP.TIME event in DELTA.T seconds if the BLUE TANK has fewer than 2 STEP.TIME events scheduled. Control is then returned to the system timer.





## E. EVENT DETECT

### Description

Event DETECT is scheduled by events STEP.TIME and IMPACT. Normal detections using routine CARDIO are scheduled by event STEP.TIME, while detections as a result of being fired upon are scheduled by event IMPACT. Depending on the defilade conditions of the observer and target, line of sight conditions between these two elements and proximity of other elements to the detected threat, detected elements may be added to the observer's detected list, target selections may be scheduled or near vicinity detections may be effected.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the observer.

B - An integer variable containing the pointer value of the target.

### Coding and Brief Explanation

The coding for event DETECT is shown below, followed by a brief explanation.

```
1  UPON DETECT(A,B)
2  DEFINE A,B AS INTEGER VARIABLES
```



```

3  DEFINE J AS AN INTEGER VARIABLE

4  IF ALIVE.DEAD(A) EQ 1

5  RETURN

6  ELSE

7  IF DEFNUM(B) EQ 1 CALL LIST.UPDATE(0,A,B,0)

RETURN ELSE

8  CALL LOC(A) CALL LOC(B)

9  CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT
(A),HTO(A),X.CURRENT(B),

10 Y.CURRENT(B),Z.CURRENT(B),HTTGT(B),P.V.(*)

11 LET PCT.VIS=P.V(1)

12 IF PCT.VIS GT CRITICAL.VALUE LET LINE.OF.SIGHT.
EXISTS=1 JUMP AHEAD ELSE

13 LET LINE.OF.SIGHT.EXISTS=0 HERE

14 IF DEFNUM(A) EQ 1 CALL LIST.UPDATE(LINE.OF.SIGHT.
EXISTS,A,B,0) RETURN ELSE

15 IF LINE.OF.SIGHT.EXISTS EQ 1 CALL PROXIMITY.DETECT
(A,B) ALWAYS

16 RETURN

17 END

```



Lines 1-2 define the routine and local variables.

Lines 3-5 insure that the observer is still alive before proceeding.

Line 6 tests the defilade condition of the target. If the target is in full defilade, (that is, he cannot be seen), then the observer is considered to have lost detection on this target and the target, if currently in the detected list, is removed from the list. The first 0 argument in the call to routine LIST.UPDATE accomplishes this, while the second 0 argument in this call prevents a target selection from being scheduled.

Line 7 updates the X, Y, and Z coordinates of the observer and target.

Lines 8-12 determine if line of sight exists between the observer and target.

Line 13 tests the defilade condition of the observer. If the observer is in full defilade, the detection may still occur if line of sight exists and the target is still alive.

Lines 14-15 allow for the possibility of near vicinity detections if line of sight exists and the observer is not in defilade. Control is then returned to the system timer.



## F. EVENT TARGET.SELECT

### Description

Event TARGET.SELECT is used by all weapon systems to select targets on the basis of highest priority within range bands. For some weapons systems, the priority criteria may be altered as a result of actions by other unit members. These actions are represented in several tactical target selection modules. The current version of STAR uses tactical target selection modules for the following weapon systems: XM1, IFV, ITV, T72, and BMP. These modules are presented in detail in later sections. In general, all weapon systems using these modules attempt to select the highest priority target that is not being engaged by another unit member. IFVs, ITVs, and BMPs will not fire if all targets in their detected list are being engaged by other unit members. In contrast, XM1s will always engage a target from their detected list assuming that the range and line of sight filters are satisfied. An XM1's engagement will be the highest priority threat not being engaged by another unit member or, if all threats are being engaged, the target selected will be the highest priority threat in the detected





list. T72s always attempt to acquire the FOE of their platoon leader. Failing this, a T72 will select its highest priority threat.

If, after a target is selected, line of sight does not exist, the target is in full defilade or the target has already been killed, the threat will be removed from the firer's detected list and a re-selection will be attempted.

If all potential targets are outside the maximum engagement range of the firer, control is returned to the system timer.

If a selection is accomplished, event FIRE is scheduled in the maximum of the time it takes to lay (aim) the weapon and load (prepare to fire) the weapon.

Two points should be clarified with respect to the variable ANSWER. An ANSWER of 0 from routine T72.TACTICS indicates that the T72 has selected his platoon leader's FOE. An answer of 1 indicates the converse. Within the loop that sequentially accesses detected threats (lines 27-47), an ANSWER of 0 means that the currently accessed threat is still a candidate for selection. An ANSWER of 1 causes this threat to be bypassed. In most cases the latter



result occurs when a threat is being engaged by another unit member.

Event TARGET.SELECT is relatively complicated and a cursory look at the tactical target selection modules prior to reading this event is recommended.

### Local Variables

The following are local variables of this event:

A - An integer variable containing the pointer value of the selecting TANK.

ID - An integer variable containing the pointer value of the selected TANK.

I - An integer counter.

ANSWER - An integer variable whose value is the result of a call to a tactical target selection module. See the Description section of this event for details.

P - An integer variable which reflects the priority of the currently accessed threat in the detected list.

OLDP - An integer variable which reflects the priority of the current candidate for selection.

RND - An integer variable which contains a coded ammunition type. This ammunition is the type desired for use against the current candidate for selection.



ENGAGED - An integer variable which takes on the value 0 or 1. Used exclusively for XM1 target selection, if ENGAGED is changed to 0 as a result of a call to routine XM1.TACTICS, only subsequent targets which are not being engaged will be candidates for selection. If ENGAGED remains 1, the XM1 will select the highest priority threat from his list, regardless of its engagement status.

WHOCALLED - An integer variable which is assigned the value 1 in event TARGET.SELECT. As an argument to routine LIST.UPDATE, a value of 1 for WHOCALLED prevents another TARGET.SELECT from occurring as a result of the detected list being updated.

R - A real variable representing the range in meters between the selecting TANK and the currently accessed threat.

OLD.RANGE - A real variable representing the range in meters between the selecting TANK and the most recent candidate for selection.

#### Coding and Brief Explanation

The coding for event TARGET.SELECT is shown below, followed by a brief explanation:



```

1  UPON TARGET.SELECT(A)

2  DEFINE R, AND OLD.RANGE AS REAL VARIABLES

3  DEFINE ANSWER, OLDP, P, RND, AIM, A, ID, I, ENGAGED,
AND WHOCALLED AS INTEGER

4  VARIABLES

5  IF DEFNUM(A) = 1 RETURN ELSE

6  IF ALIVE.DEAD(A) EQ 1 RETURN

7  ELSE

8  IF FIP(A) EQ 1 RETURN

9  ELSE

10 IF SCHED(A)=1

11 RETURN

12 ELSE

13 IF WPN.TYPE(A) EQ 7 CALL T72.TACTICS(A) YIELDING
ANSWER

14 IF ANSWER EQ 0 RETURN ELSE

15 ALWAYS

16 'SELECT'

17 CALL LOC(A)

18 'TRY.AGAIN'

19 LET LIST(*)=TARGET(NAME(A),1)

20 IF LIST(1) EQ 0

```





```

21- LET LIST LIST(*) = 0

22 RETURN

23 ELSE

24 LET ENGAGED = 1 LET WHOCALLED = 1 LET OLDP = 99

LET OLD.RANGE = 99999

25 FOR I=1 TO DIM.F(LIST(*)), DO

26 CALL LOC(LIST(I))

27 CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT
(POINTER(LIST(I))),
28 Y.CURRENT(POINTER(LIST(I)))) YIELDING R

29 LET RANGE(A) = R

30 GO TO XM1, XM1, IFV, ITV, DIVAD, DRAGON, T72, BMP,
ZSU PER WPN.TYPE(A)

31 'IFV' CALL IFV.TACTICS(A,LIST(I)) YIELDING ANSWER
GO TO NEXT

32 'ITV' CALL ITV.TACTICS(A,LIST(I)) YIELDING ANSWER
GO TO NEXT

33 'DIVAD' LET ANSWER = 0 GO TO NEXT

34 'DRAGON' LET ANSWER = 0 GO TO NEXT

35 'T72' LET ANSWER = 0 GO TO NEXT

36 'BMP' CALL BMP.TACTICS(A,LIST(I)) YIELDING ANSWER
GO TO NEXT

```



```

37  'ZSU'  LET ANSWER = 0 GO TO NEXT

28  'NEXT' IF ANSWER EQ 1 GO TO LOOP ELSE GO TO NORMAL.

SELECT

39  'XML' CALL XML.TACTICS(A,LIST(I))  YIELDING ANSWER

40  'NORMAL.SELECT' CALL PRIORITY.AND.ROUND.SELECT(A,

LIST(I)) YIELDING P, RND

41  IF P EQ 99 GO TO LOOP ELSE

42  IF ANSWER LT ENGAGED GO TO REPLACE ELSE

43  IF (( P LT OLDP) OR (P EQ OLDP AND R LE OLD.RANGE))

AND (ANSWER EQ ENGAGED)

44  'REPLACE' LET OLDP=P LET OLD.RANGE=R LET PROJO(A)=

RND LET ID=LIST(I)

45  LET ENGAGED = ANSWER REGARDLESS 'LOOP' LOOP

46  LET LIST(*) = 0

47  IF OLD.RANGE LE OP.RNG(A)

48  JUMP AHEAD

49  ELSE

50  RETURN

51  HERE

52  CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT

(A),HTO(A),

```



```

53      X.CURRENT(ID),Y.CURRENT(ID),Z.CURRENT(ID),
HTTGT(ID),P.V(*)

54  LET PCT.VIS=P.V(1)

55  IF PCT.VIS GT CRITICAL.VALUE  LET LINE.OF.SIGHT.
EXISTS=1

56  JUMP AHEAD ELSE

57  LET LINE.OF.SIGHT.EXISTS=0  HERE

58  IF LINE.OF.SIGHT.EXISTS  EQ 0

59  OR ALIVE.DEAD(ID) EQ 1

60  OR DEFNUM(ID) EQ 1

61  CALL LIST.UPDATE(0,A,ID,WHOCALLED)

62      GO TO TRY.AGAIN

63  ELSE

64  LET RANGE(A) = OLD.RANGE

65  LET FOE(A)=ID

66  LET SCHED(A)=1

67  SCHEDULE A FIRE(A,ID) IN MAX.F(UNIFORM.F(10.,20.,3),
UNIFORM.F(8.,16.,4))

68      UNITS

69  LET CHECK.TIME(A) = TIME.A(FIRE)

70  RETURN

71  END

```



Lines 1-4 define the event and local variables.

Lines 5-11 return control to the system timer if the selecting TANK is in full defilade, is dead, has a firing in progress, or has a fire scheduled.

Lines 12-16 apply only to weapons of type T72. The T72 attempts to acquire his platoon leader's FOE and schedule a FIRE event on this target. If this occurs, control is returned to the system timer. Otherwise, the T72 selects his highest priority threat in a manner similar to other weapon systems.

Lines 17-23 update the X, Y, and Z coordinates of the selecting TANK and access the TANK's list of detected threats. If the list contains no potential targets, control returns to the system timer. Otherwise, execution continues.

Line 24 sets default values for local variables.

Line 25 sequentially accesses elements in the TANK's list of detected threats.

Lines 26-29 update the X, Y, and Z coordinates of the currently accessed threat. The range between the TANK and this threat is calculated and the TANK's RANGE attribute is set to this value.





Line 30 transfers control to the appropriate label based on the weapon type of the TANK.

Lines 31-37 call a tactical target selection module, if required, and transfer control to the label 'NEXT'.

Line 38 tests the ANSWER returned above and transfers control to label 'LOOP' if ANSWER = 1, or to label 'NORMAL. SELECT' if ANSWER = 0.

Line 39 calls the tactical routine for XMLs.

Line 40 returns a priority and desired ammunition type to be used against the current threat.

Line 41 transfers control to label 'LOOP' if the priority returned is equal to 99. This indicates that the target cannot be engaged.

Line 42 allow XMLs to give higher priority to targets which are not being engaged. Any target not being engaged can replace a target which is being engaged.

Line 43 tests the values of P, R, and ANSWER against the values of OLDP, OLD.RANGE, and ENGAGED. To replace a threat as the current candidate for selection, the target must have a higher priority or, if it has the same priority, must be closer in range. Moreover, it must have the same engagement status as the current threat. This last condition



is always satisfied for weapons other than XMLs. If the test fails, control transfers to label 'LOOP'.

Lines 44-45 set local variables to values associated with the new threat. If the threat list has not been exhausted, the cycle begins again with line 27.

Line 46 releases the list of detected threats.

Lines 47-51 insure that the range to the selected threat is within the opening range of the TANK. If not, control returns to the system timer. Otherwise, execution continues.

Lines 52-57 calculate the percentage of the target visible to the selecting TANK. Line of sight is set to 1 if the percentage returned exceeds a user defined value.

Lines 58-62 remove the currently selected threat from the list and allow another selection (label 'TRY AGAIN') if the selected threat is dead, is in full defilade or cannot be seen.

Lines 63-66 set the TANK's RANGE attribute to the current range to the target, set the FOE attribute to the pointer value of the target, and set the scheduled to fire attribute, SCHED, to 1.



Lines 67-70 schedule a FIRE event on the selected target, set the TANK's CHECK.TIME attribute to the time for which the FIRE event is scheduled to occur, and return control to the system timer.

#### G. EVENT FIRE

##### Description

Event FIRE may be scheduled by event TARGET.SELECT, routine T72.TACTICS, and routine WE.MISS. Event FIRE is scheduled in the maximum of two times: the time it takes to aim the weapon (lay time), and the time it takes to prepare the weapon for firing (load time). For second round shots at the same target after a miss, only load time is considered. The weapon is assumed to be laid on the target.

##### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the firing TANK.

ID - An integer variable containing the pointer value of the target TANK.



STOPCOUNT - An integer variable with a value of 1 when used in event FIRE. This value is used as an argument in routine STOP.TO.FIRE to indicate that the weapon system must stop prior to firing.

#### Coding and Brief Explanation

The coding for event FIRE is shown below, followed by a brief explanation:

```
1  UPON FIRE(A,ID)
2  DEFINE STOPCOUNT AS AN INTEGER VARIABLE
3      DEFINE A AS AN INTEGER VARIABLE
4  DEFINE ID AS AN INTEGER VARIABLE
5      DEFINE R AS A REAL VARIABLE
6  LET SCHED(A)=0
7  LET STOPCOUNT=1
8  IF DEFNUM(A) EQ 1 LET FOE(A) = 0 RETURN ELSE
9  IF DEFNUM(ID) EQ 1 GO TO RE.SELECT ELSE
10 CALL LOC(A)    CALL LOC(ID)
11                IF FOE(A) NE ID RETURN
12                ELSE
13 IF CHECK.TIME(A) NE TIME.V RETURN ELSE
14 IF FIP(A) EQ 1 RETURN ELSE
15 IF ALIVE.DEAD(A) EQ 1 RETURN
```





```

16- ELSE

17  IF ALIVE.DEAD(ID) EQ 1

18  'RE.SELECT'

19  LET FOE(A) = 0

20  LET SECOND.SHOT(A) = 0

21                                LET FIP(A) = 0

22  SCHEDULE A TARGET.SELECT(A) NOW

23  RETURN

24                ELSE

25  CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT
(POINTER(ID)),

26          Y.CURRENT(POINTER(ID))) YIELDING R

27  IF R GT OP.RNG(A)

28  LET FIP(A)=0

29  LET FOE(A)=0

30  SCHEDULE A TARGET.SELECT(A) NOW

31  RETURN

32  ELSE

33  CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT
(A), HTO(A), X.CURRENT(ID),

34  Y.CURRENT(ID), Z.CURRENT(ID), HTTGT(ID), P.V(*)

```



```

35 LET PCT.VIS=P.V(1)
36 IF PCT.VIS LT CRITICAL.VALUE
37 GO TO RE.SELECT
38 ELSE
39 IF COLOR(A) EQ BLUE LET DEFNUM(A) = 3 ALWAYS
40 LET FIP(A) = 1
41 LET RANGE(A) = R
42 IF WPN.TYPE(A) EQ 8 OR WPN.TYPE(A) EQ 3 OR WPN.
TYPE(A) EQ 4
43 CALL STOP.TO.FIRE(A,STOPCOUNT)
44 ALWAYS
45 CALL SET.MUZZLE.VEL(A)
46 SCHEDULE AN IMPACT(A,ID) IN R/MZL.VEL(A) UNITS
47 RETURN
48 END

```

Lines 1-6 define the routine and local variables.

Line 7 resets the scheduled to fire attribute to 0.

Line 8 assigns STOPCOUNT a value of 1.

Line 9 tests to insure that the firer is not in full  
defilade before proceeding.



Line 10 tests to insure that the target is not in full defilade before proceeding. If the target is in full defilade, flow is transferred to a point where another tank selection can be made (see label 'RE.SELECT').

Line 11 updates the X, Y, and Z coordinates of the firer and target.

Lines 12-13 insure that the current FOE is the one for which this FIRE event was scheduled.

Line 14 insures that this is the correct FIRE event by matching elapsed simulated time with the time that this tank's last fire was scheduled to occur.

Line 15 prevents this FIRE if the firer already has a firing in progress.

Lines 16-17 prevent this FIRE if the firer is dead.

Lines 18-25 prevent this FIRE if the target is already dead. If this is the case, the firer's FOE, SECOND.SHOT, and firing in progress attributes are reset to 0. An immediate target selection is scheduled, and control is returned to the system timer.

Lines 26-27 calculate the current distance in meters between the target and firer.



Lines 28-31 insure that the target is within the maximum opening range of the firer. If this is not the case, the FIP and FOE attributes are reset to 0, and control is returned to the system timer.

Lines 32-35 calculate the percentage of the target that is visible to the firer.

Lines 36-37 return control to the system timer if the target's percentage visible is less than the user defined value.

Lines 38-39 place BLUE firers in firing defilade.

Lines 40-41 set the firing in progress attribute to 1 and the range attribute to the current range between firer and target.

Lines 42-43 halt missile firing weapon systems prior to firing.

Lines 44-47 calculate the muzzle velocity for the type of ammunition being fired and schedule an IMPACT event in an amount of time equal to the time of flight of the round. Control is then returned to the system timer.





## H. EVENT IMPACT

### Description

Event IMPACT is scheduled by event FIRE. Once a round is fired, event IMPACT is always allowed to occur. If the firer scores a catastrophic kill (K-kill), the target's HIT.STATE attribute is changed to "DEAD", the ALIVE.DEAD attribute is set to 1, the target is removed from the firer's detected list, and the appropriate hit counters are incremented for the target. Missile firing weapons are restarted from their firing positions and routine WE.HIT determines the next action for the firer.

Anything other than a catastrophic kill causes the MISS section of event IMPACT to be activated. A detection of the firer is scheduled in an amount of time dependent on the firer's location with respect to the target. Missile firing weapons are moved from their firing positions, routine WE.MISS determines the next action for the firer and the appropriate hit counters are incremented for the target.

Results of the IMPACT event are then printed and control is returned to the system timer.



## Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the firer.

ID - An integer variable containing the pointer value of the target.

WHOCALLED - An integer variable set equal to 10 in event IMPACT which allows a target selection to occur when the detected list is updated by the removal of a dead target.

STOPCOUNT - An integer variable set equal to 2 in event IMPACT which restarts missile firing weapon systems when routine STOP.TO.FIRE is called.

DT - A real variable used to set the time of detection of the firer by the target. DT assumes one of two values input by the user. These values are dependent on whether or not the firer is in the target's search sector.

X - A real variable which assumes a random value from a uniform (0,1) probability distribution.

DAMAGE.NUM - An integer variable which is assigned the value 5 if the firer scores a catastrophic kill and the value 6 otherwise.



## Coding and Brief Explanation

The coding for event IMPACT is shown below, followed by a brief explanation:

```
1  UPON IMPACT(A, ID)
2  DEFINE STOPCOUNT AS AN INTEGER VARIABLE
3      DEFINE A AND ID AS INTEGER VARIABLES
4  DEFINE DAMAGE.NUM AND ANSWER AS INTEGER VARIABLES
5  DEFINE WHOCALLED AS AN INTEGER VARIABLE
6  DEFINE DT AS A REAL VARIABLE
7      DEFINE X AS A REAL VARIABLE
8  LET FIP(A)=0
9  CALL DECREMENT.AMMO(A, PROJO(A))
10 LET WHOCALLED=10
11 LET STOPCOUNT=2
12 IF DEFNUM(ID) EQ 1 LET HIT.STATE(ID) = "HIDE" GO TO
MISS ELSE
13 CALL LOC(A)    CALL LOC(ID)
14 IF (WPN.TYPE(A) EQ 6 OR (WPN.TYPE(A) EQ 3 AND PROJO
(A) EQ 1) OR
15      (WPN.TYPE(A) EQ 8 AND PROJO(A) EQ 1) OR WPN.
TYPE(A) EQ 4)
```



```

16  AND ALIVE.DEAD(A) EQ 1  GO TO MISS2 ELSE

17  CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT
(A), HTO(A); X.CURRENT(ID),

18  Y.CURRENT(ID), Z.CURRENT(ID), HTTGT(ID), P.V(*)

19  LET PCT.VIS=P.V(1)

20  IF PCT.VIS LT CRITICAL.VALUE

21  GO TO MISS ELSE

22  CALL COMPUTE(A,ID,PCT.VIS)

23      LET FOE(A)=0

24  IF COLOR(A) EQ RED AND X GE 1-PH(A)/2  OR COLOR(A)
EQ BLUE AND X GE 1-PH(A)

25      LET FOE(A)=0

26      LET ALIVE.DEAD(POINTER(ID))=1

27  LET HIT.STATE(ID)="DEAD"

28  LET DAMAGE.NUM=5

29  CALL TALLY.HIT.STATE(ID,DAMAGE.NUM)

30  CALL LIST.UPDATE(0,A,ID,WHOCALLED)

31  IF WPN.TYPE(A) EQ 8 OR WPN.TYPE(A) EQ 3 OR WPN.
TYPE(A) EQ 4

32  CALL STOP.TO.FIRE(A,STOPCOUNT)

33  ALWAYS

34  CALL WE.HIT(A)

```





```

35             GO TO OUT
36 ELSE
37 'MISS'
38     ''WE DID NOT KILL THE TANK''
39 LET DT=MMM
40 CALL SECTOR.CHECK(ID,A) YIELDING ANSWER
41 IF ANSWER EQ 1 LET DT=NNN ALWAYS
42 SCHEDULE A DETECT(ID,A) IN DT UNITS
43 IF WPN.TYPE(A) EQ 8 OR WPN.TYPE(A) EQ 3 OR WPN.
TYPE(A) EQ 4
44 CALL STOP.TO.FIRE(A,STOPCOUNT)
45 ALWAYS
46 CALL WE.MISS(A)
47 'MISS2'
48 LET DAMAGE.NUM=6
49 CALL TALLY.HIT.STATE(ID,DAMAGE.NUM)
50 'OUT'
51 CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT(ID),
Y.CURRENT(ID)) YIELDING R
52 PRINT 1 LINE WITH TTT,NAME(A),QQ(WPN.TYPE(A)),PROJO
(A),NAME(ID),QQ(WPN.TYPE(ID))

```



```

53  ,TIME.V,HIT.STATE(ID), R,X.CURRENT(A),Y.CURRENT(A),
X.CURRENT(ID),Y.CURRENT(ID)      THUS

```

54

```

** ** ***** * ** ***** *** ***** ***** ***** ***** *****

```

```

55  LET TTT = TTT = 1

```

```

56  'NEXT'

```

```

57  IF HIT.STATE(ID) EQ "DEAD" JUMP AHEAD ELSE

```

```

58  LET HIT.STATE(ID) = " "

```

```

59  HERE

```

```

60  IF N.READ.ALIVE LE INT.F(BC.COUNT*(1-R.PCT.ATT))

```

```

61  OR N.BLUE.ALIVE LE INT.F(RC.COUNT*(1-B.PCT.ATT))

```

```

62  SCHEDULE A STOP.SIMULATION IN 15.0 UNITS

```

```

63      ALWAYS

```

```

64  RETURN      END

```

Lines 1-7 define the event and local variables.

Line 8 resets the firing in progress attribute to 0.

Line 9 reduces the firer's ammunition count by 1 unit of the type fired.

Lines 10-11 assign values to WHOCALLED and STOPCOUNT.

Line 12 checks the defilade status of the target. If the target is in full defilade, control is transferred to the MISS section of the event.



Line 13 updates the X, Y, and Z coordinates of the firer and target.

Lines 14-16 check the ALIVE.DEAD status of missile firers. If the firer is dead prior to the impact of his missile, the missile is considered ineffective and control transfers to the MISS2 section of the event.

Lines 17-19 calculate the percentage of the target visible to the firer.

Lines 20-21 transfer control to the MISS section of the event if the percentage of the target visible to the firer is less than the user defined value.

Line 22 calculates the probability of hit using routine COMPUTE. Note that a hit is synonymous with a kill in the current version of STAR.

Line 23 draws a random number from a Uniform(0,1) probability distribution.

Line 24 tests the random number X against the probability of hit computed in line 22. If X is greater than 1-probability of hit, the target is considered killed and the next block of code is executed; otherwise, control transfers to the MISS section of the event.



Lines 25-28 reset the firer's FOE attribute to 0, change the ALIVE.DEAD attribute to "DEAD", and assign the value 5 (indicating a catastrophic kill) to the variable DAMAGE.NUM.

Line 29 updates the target's hit counters.

Line 30 removes the target from the firer's detected list.

Lines 31-32 restart firers who had stopped to fire.

Lines 33-35 determine the next action for the firer and transfer control to the output section of the event.

Lines 36-38 define and label the MISS section of the event.

Line 39 sets the detection time of the firer by the target to a default value of MMM units (currently 6 seconds).

Line 40 determines if the firer is in the target's sector.

Lines 41-42 reset DT to a value of NNN units (currently 2 seconds) if the firer is in the target's sector. A detection of the firer by the target is scheduled to occur in DT units.

Lines 43-44 restart firers who had stopped to fire.

Lines 45-49 determine the next action for the firer and update the target's hit counters.





Lines 50-54 calculate the current range to the target and print information pertinent to the engagement.

Line 55 increments by one the total rounds fired counter.

Lines 56-59 reset the HIT.STATE attribute to four blank spaces if previously set to anything other than "DEAD".

Lines 60-64 stop the simulation if either RED or BLUE forces have reached 100 percent attrition. Control is then returned to the system timer.

## I. EVENT HIDE

### Description

Event HIDE is used to change the defilade number of a weapon system. Although defilade numbers may be changed anywhere in the program, the use of an event allows the user to change from one condition to another in a specified or random amount of time. Currently, event HIDE is used by events FIRE and IMPACT to bring the element to firing defilade upon engagement of a target, to allow the element to achieve full cover after a firing sequence (dependent on weapon type) and to allow the element to return to turret defilade after an appropriate passage of time under full cover.



Currently, only a DEFNUM equal to 1 (fully covered) has an effect on the execution of STAR. In event STEP.TIME, a DEFNUM of 1 causes a loss of knowledge of previously detected targets. In event DETECT two cases exist. If the observer is in full defilade, the detection is allowed to occur, but no target selection event is scheduled. This models the "corporate memory" of the TANK crew when the TANK returns to turret defilade. If the target is in full defilade, the target is removed from the observer's list of detected targets. Event TARGET.SELECT is cancelled if the selecting TANK is in full defilade. If a potential target is in full defilade, that target cannot be selected. Event FIRE is cancelled if the firer is in full defilade. If the target is in full defilade prior to the impact of the round, the round will be assessed as a miss in event IMPACT.

#### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK for which a change in defilade is required.

WHOCALLED - An integer variable which assumes values 1 through 5 depending on the type of defilade change required.



WHOCALLED keys the computed go to statement to access the correct label in the code.

### Coding and Brief Explanation

The coding for event HIDE is shown below, followed by a brief explanation:

```
1  UPON HIDE(A,WHOCALLED)
2  DEFINE A AND WHOCALLED AS INTEGER VARIABLES
3  GO TO FULL, TURRET, FIRING, STOP, OTHER PER WHOCALLED
4  'FULL' LET DEFNUM(A) = 1 SCHEDULE A HIDE(A,2) IN
DEF.TIME UNITS RETURN
5  'TURRET' LET DEFNUM(A) = 2 RETURN
6  'FIRING' LET DEFNUM(A) = 3 RETURN
7  'STOP' LET DEFNUM(A) = 4 RETURN
8  'OTHER' LET DEFNUM(A) = 5 RETURN  END
```

Lines 1-2 define the event and local variables.

Line 3 uses a computed go to statement to access the correct defilade number change instructions in the code.

Line 4 places the TANK in full defilade and schedules a HIDE with a WHOCALLED value of 2 in 20 seconds. When this scheduled HIDE occurs, the WHOCALLED value of 2 will access the next line of code and change the defilade number to 2, turret defilade.



Line 5 changes the defilade number to 2, turret defilade.

Line 6 changes the defilade number to 3, firing defilade.

Line 7 changes the defilade number to 4. This type of defilade indicates that the TANK is attempting to acquire concealment.

Line 8 changes the defilade number to 5, a fully exposed position. In all cases above, control is returned to the system timer.

#### J. EVENT ATTRITION.CHECK

##### Description

Event ATTRITION.CHECK is used to test the number of BLUE and RED TANKs remaining at specified times during the simulated battle. If either number of survivors falls below the user defined attrition percentage, event STOP. SIMULATION is scheduled in 15 seconds following execution of event ATTRITION.CHECK. This time delay is intended to allow any rounds in the air (especially missiles) to impact prior to halting the simulation.

The user may initially schedule this event in routine MAIN at a point in the battle where he feels that casualties will begin to approach his input attrition thresholds. Alternatively, this event could be scheduled as soon as





simulation begins. After the first occurrence of the event, ATTRITION.CHECK schedules itself every DELTA.T seconds.

### Local Variables

There are no local variables in this event.

### Coding and Brief Explanation

The coding for event ATTRITION.CHECK is shown below, followed by a brief explanation:

```
1  UPON ATTRITION.CHECK
2  IF N.RED.ALIVE LE INT.F(BC.COUNT*(1-R.PCT.ATT))
3  OR N.BLUE.ALIVE LE INT.F(RC.COUNT*(1-B.PCT.ATT))
4  SCHEDULE A STOP.SIMULATION IN 15.0 UNITS
5  ALWAYS
6  SCHEDULE AN ATTRITION.CHECK IN DELTA.T UNITS
7  RETURN END
```

Line 1 defines the event.

Line 2 compares the number of TANKS remaining in the RED.ALIVE set to the integer number of TANKs corresponding to the user's RED attrition percentage input.

Line 3 performs the same test for BLUE TANKs.

Line 4 schedules a halt to the simulation in 15 seconds if either line 2 or line 3 is true.

Simulation begins. After the first occurrence of the error.

EXPLANATION: The error is caused by the fact that the

Lines 5-7 reschedule this event in DELTA.T seconds and return control to the system timer.

#### K. EVENT FINAL.DEATH

##### Description

Event FINAL.DEATH changes the ALIVE.DEAD attribute of a TANK to 1 sixty seconds after the TANK sustains a mobility and firepower kill. This event is scheduled by routine COMPUTE.

##### Local Variable

The following is a local variable of this routine:

A - An integer variable containing the pointer value of the TANK for which an ALIVE.DEAD attribute change is required.

##### Coding and Brief Explanation

The coding for event FINAL.DEATH is shown below. This event is self explanatory.

```
1  UPON FINAL.DEATH(A) DEFINE A AS AN INTEGER VARIABLE
LET ALIVE.DEAD(A)=1 RETURN END
```

#### L. EVENT STOP.SIMULATION

##### Description

Event STOP.SIMULATION is used to return control of the program to routine MAIN and bring execution of the program



to a halt. This event is scheduled by either event STEP.TIME or event IMPACT. If event STEP.TIME causes execution of this event, then a RED TANK has crossed an X and Y coordinate threshold defined in the event STEP.TIME. If event IMPACT causes execution of this event, then either the BLUE or RED forces have reached an attrition point threshold defined in routine MAIN. In addition to printing the elapsed simulated time in seconds, the number of line of sight calls are printed and the current attrition values of each weapon system are printed.

The coding for event STOP.SIMULATION is shown below. There are no local variables in this event and the code is self explanatory.

```
1  UPON STOP.SIMULATION
2  PRINT 1 LINE WITH TIME.V AND LIN THUS
SIMULATION STOPPED AT  *****.*****  LOS CALLS = *****
3  SKIP 3 OUTPUT LINES
4  FOR EACH TANK IN TANKS CALL LOC(TANK)
5  LIST ATTRIBUTES OF EACH TANK IN TANKS
6  STOP
7  END
```



## M. ROUTINE SET.SECTOR

### Description

Routine SET.SECTOR is used to provide unit vector endpoints in the direction of the left and right search sector limits of a particular weapon system. A simple rotation matrix is applied to the primary direction of search. This matrix multiplication produces the required endpoints. Routine SET.SECTOR is used when weapons systems are created and any time that the primary direction of search changes. Currently, the MAIN routine and routine CHG.SEC.SEARCH use routine SET.SECTOR for these purposes. See event STEP.TIME for conditions that activate routine CHG.SEC.SEARCH.

### Local Variables

The following are local variables of this routine:

TANK - An integer variable containing the pointer value of the weapon system for which the left and right sector limits are being developed.

X - The X coordinate of a unit vector in the direction of the current primary direction of search.

Y - The Y coordinate of a unit vector in the direction of the current primary direction of search.





A - A real variable which has the value of the cosine of one-half the current search sector angle.

B - A real variable which has the value of the sine of one-half the current search sector angle.

WIDTH - One-half the current search sector angle in radians.

#### Coding and Brief Explanation

The coding for routine SET.SECTOR is shown below, followed by a brief explanation.

```
1  ROUTINE SET.SECTOR(TANK)
2  DEFINE TANK AS AN INTEGER VARIABLE
3  DEFINE X,Y,WIDTH,A,B AS REAL VARIABLES
4  LET X = COS.F(PRI.DIR(TANK))  LET Y = SIN.F(PRI.DIR
(TANK))
5  LET WIDTH =(AREA/2.0) * PI.C * 2.0 / 360.0
6  LET A = COS.F(WIDTH)  LET B = SIN.F(WIDTH)
7  LET X.R(TANK) = A*X + B*Y
8  LET Y.R(TANK) = -B * X + A*Y
9  LET X.L(TANK) = A*X + (-B) * Y
10 LET Y.L(TANK) = B*X + A *Y
11 RETURN END
```



Lines 1-3 define the routine and local variables.

Line 4 calculates the endpoints of a unit vector in the direction of the primary direction of search.

Line 5 calculates the value of one-half the current search sector angle.

Line 6 calculates the sine and cosine required for the rotation matrix.

Lines 7-11 calculates the X and Y endpoints of unit vectors in the direction of the left and right search sector limits, respectively. Control is then returned to the routine MAIN or routine CHG.SEC.SEARCH. The rotation matrix, R, represented by these lines of code is shown below. Note that any positive or negative angle may be substituted for WIDTH.

$$R = \begin{bmatrix} \text{COS(WIDTH)} & \text{SIN(WIDTH)} \\ -\text{SIN(WIDTH)} & \text{COS(WIDTH)} \end{bmatrix}$$

## N. ROUTINE LOC

### Description

Routine LOC is a simplified movement routine used in the basic version of STAR. It is called by numerous routines and events throughout STAR, and is used to update



the X, Y, and Z coordinates of a particular TANK. In the current version of STAR, BLUE TANKs do not move. An assumption of instantaneous acceleration to constant speed is made, as is the assumption of instantaneous deceleration to a speed of zero. The Z coordinate, elevation, is obtained from FORTRAN routine ELEV which resides on disk. An elevation floor of 250 meters is used to save line of sight computation time in FORTRAN routine LOS. The movement routine for production versions of STAR will be a FORTRAN routine.

#### Local Variables

The following is a local variable of this routine:

TANK - An integer variable containing the pointer value of the element for which a location update is required.

#### Coding and Brief Explanation

The coding for routine LOC is shown below, followed by a brief explanation:

```
1  ROUTINE LOC(TANK)
2  DEFINE TANK AS AN INTEGER VARIABLE
3  IF ALIVE.DEAD(TANK) EQ 1 OR COLOR(TANK) EQ BLUE RETURN
ELSE
```



```

4 LET X.CURRENT(TANK)=X.CURRENT(TANK)+(TIME.V-T.SPD
(TANK))*(SPD(TANK)
5 *COS.F(DIR.OF.MVMT(TANK)))
6 LET Y.CURRENT(TANK)=Y.CURRENT(TANK)+(TIME.V-T.SPD
(TANK))*(SPD(TANK)
7 *SIN.F(DIR.OF.MVMT(TANK)))
8 LET T.SPD(TANK)=TIME.V
9 CALL ELEV GIVEN X.CURRENT(TANK),Y.CURRENT(TANK),
ZH(*)
10 IF ZH(1) LE 250.0 LET ZH(1) = 250.0 ALWAYS LET
Z.CURRENT(TANK) = ZH(1)
11 RETURN
12 END

```

Lines 1-2 define the routine and local variable.

Line 3 insures that the tank is alive and is not BLUE before proceeding.

Lines 4-5 calculate the new X coordinate by adding to the current X coordinate the total distance traveled since the speed was last set.

Lines 6-7 calculate the current Y coordinate in a similar manner.





Lines 10-11 calculate the current elevation using FORTRAN routine ELEV. A minimum elevation of 250 meters is set and control is returned to the calling routine or event.

## 0. ROUTINE DIST

### Description

Routine DIST is used by many events and routines in STAR when the range in meters between two selected TANKs is required.

### Local Variables

The following are local variables of this routine:

X1 - The current X coordinate of the first TANK.

Y1 - The current Y coordinate of the first TANK.

X2 - The current X coordinate of the second TANK.

Y2 - The current Y coordinate of the second TANK.

DISTANCE - The return argument of routine DIST which represents the range in meters between the two selected TANKs.

### Coding and Brief Explanation

The coding for routine DIST is shown below. This routine is self explanatory.



```

1  ROUTINE FOR DIST GIVEN X1,Y1,X2,Y2 YIELDING DISTANCE
2      LET DISTANCE=SQRT.F((X1-X2)**2 + (Y1-Y2)**2)
3  RETURN
4  END

```

#### P. ROUTINE SECTOR.CHECK

##### Description

Routine SECTOR.CHECK uses the definition of the dot product of two vectors to determine if a target is within an observer's search sector. In the current version of STAR, a search sector is defined in routing MAIN to be 90 degrees, the cosine of which is 0. Recall that the cosine of an angle can be defined as:

$$\text{COSINE } \theta = (A \cdot B) / |AB|$$

where  $\theta$  is the angle between two vectors, A and B,  $A \cdot B$  is the dot product of the two vectors, and  $|AB|$  is the magnitude of a vector constructed between the end points of the given vectors. If the angle between the observer's left sector limit and the target has a cosine of less than 0, or if the angle between the observer's right sector limit and target has a cosine of less than 0, then the target is not within the observer's sector. Since routine CARDIO considers only those targets within sector, routine SECTOR.CHECK is used as



a filter prior to calling routine CARDIO in event STEP.TIME.  
Routine SECTOR.CHECK is currently used by events STEP.TIME  
and IMPACT.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of  
the observer TANK.

B - An integer variable containing the pointer value  
of the target TANK.

ANSWER - An integer variable which assumes the value 1 if  
the target is within the observer's sector, and the value 0  
if the target is not in sector.

X.T - The X coordinate of the endpoint of the vector  
from the observer to the target.

Y.T - The Y coordinate of the endpoint of a vector from  
the observer to the target.

C.LEFT - The cosine of the angle between the target and  
the observer's left sector limit.

C.RIGHT - The cosine of the angle between the target  
and the observer's right sector limit.

R - The magnitude,  $|AB|$ , described above.



## Coding and Brief Explanation

The coding for routine SECTOR.CHECK is shown below, followed by a brief explanation:

```
1  ROUTINE SECTOR.CHECK(A,B) YIELDING ANSWER
2  DEFINE A,B, AND ANSWER AS INTEGER VARIABLES
3  DEFINE X.T, Y.T, C.LEFT, C.RIGHT, AND R AS REAL
VARIABLES
4  LET ANSWER = 1
5  LET X.T = X.CURRENT(B) - X.CURRENT(A)    LET Y.T =
Y.CURRENT(B) - Y.CURRENT(A)
6  LET R= SQRT.F(((ABS.F(X.L(A)+X.T))**2.0)+((ABS.F
(Y.L(A)+Y.T))**2.0))
7  LET C.LEFT= (X.L(A)*X.T+Y.L(A)*Y.T)/R
8  LET C.RIGHT= (X.R(A)*X.T+Y.R(A)*Y.T)/R
9  IF C.LEFT LT CONSTANT OR C.RIGHT LT CONSTANT LET
ANSWER=0 ALWAYS RETURN END
```

Lines 1-3 define the routine and local variables.

Line 4 sets the default value of ANSWER to 1.

Line 5 calculates the endpoints of a vector to the target with respect to the observer.

Line 6 calculates the magnitude,  $|AB|$ , described above.





Lines 7-8 calculate C.LEFT and C.RIGHT respectively.

Line 9 tests C.LEFT and C.RIGHT against CONSTANT, the cosine of 90 degrees in the current version. If either cosine is less than zero, the target is considered to be out of sector, ANSWER is set to 0, and control is returned to the calling event.

#### Q. ROUTINE CHG.SEC.SEARCH

##### Description

Routine CHG.SEC.SEARCH is called by event STEP.TIME whenever a particular vehicle has no currently detected targets in its target list. CHG.SEC.SEARCH changes a vehicle's primary direction of search to allow a vehicle to search areas other than the original area assigned to the vehicle.

The primary direction of search is in relation to the vehicle's direction of movement. The attribute PRI.DIR is the vehicle's primary direction of search. The attribute DIR.OR.MVMT is the vehicle's direction of movement. The routine CHG.SEC.SEARCH changes the PRI.DIR attribute of a specified vehicle from zero to  $\pi/4$ ,  $\pi/4$  to  $-\pi/4$ , or  $-\pi/4$



to zero depending on the current PRI.DIR attribute of the vehicle when the routine is called.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the vehicle for which a change of sector is to be accomplished.

XYZ - An integer variable used to direct a computed go to statement to the proper label.

The coding for CHG.SEC.SEARCH is shown below, followed by a brief explanation:

```
1  ROUTINE CHG.SEC.SEARCH(A)
2  DEFINE A AND XYZ AS INTEGER VARIABLES
3  LET XYZ = SIGN.F(PRI.DIR(A)-DIR.OF.MVMT(A))
4  LET XYZ=XYZ+2
5  GO TO C1,C2,C3  PER XYZ
6  'C1' LET PRI.DIR(A) = 0. + DIR.OF.MVMT(A)  GO TO SET
7  'C2' LET PRI.DIR(A) = PI.C/4 + DIR.OF.MVMT(A)  GO
TO SET
8  'C3' LET PRI.DIR(A) = -PI.C/4. + DIR.OF.MVMT(A)  GO
TO SET
```



```
9  'SET'      CALL SET.SECTOR(A)
10 RETURN     END
```

Lines 1-2 define the routine and local variables.

Line 3 uses the SIGN.F system function to set the initial value of XYZ. If the argument is zero XYZ=0, if the argument is positive XYZ=1, if the argument is negative XYZ=-1.

Line 4 adds 2 to XYZ for use in the computed go to statement

Line 5 directs the routine to label 'C1' if XYZ=1, to label 'C2' if XYZ=2, and to label 'C3' if XYZ=3.

Lines 6-8 set the new primary direction of search on the appropriate vehicle.

Line 9 calls routine SET.SECTOR which resets the sector limits of the appropriate vehicle based on the new primary direction of search.

Line 10 returns control to the calling routine or event.

## R. ROUTINE CARDIO

### Description

Routine CARDIO is called by event STEP.TIME whenever it is necessary to determine how long it will take (in seconds) for an observer to detect a given target. This routine uses



the assumption that detection is a random phenomenon. The basic detection equation used in the routine is:

$$P(d)=1-\exp(-\text{LAMBDA} * t)$$

where:  $P(d)$  is the probability of detection

$\text{LAMBDA}$  is the detection rate

$t$  is the time to detect

The routine draws a random number from a uniform(0,1) distribution as the value of  $P(d)$ , then solves for  $t$  and returns the value of  $t$  to STEP.TIME.

Routine CARDIO assigns a uniform probability of an observer looking in each 30 degree portion of his search area. (Area size in degrees is user specified.) Thus, if the observer's search area is 90 degrees he has a one-third probability of looking in each 30 degree portion of his search area at a specified time. If the user specifies 360 degrees as the search area, routine CARDIO utilizes a cardioid distribution to determine probability of looking in any particular 30 degree portion of the search area.

The value of  $\text{LAMBDA}$  used in the detection equation is calculated using the following formula [Ref. 10]:

$$\text{LAMBDA} = .003 + \frac{1.088}{1.453 + \text{TC.FACTOR} * (.5978 + 2.136 * (\text{RR} ** 2) - .5036 * \text{X.VELOCITY})}$$





where: T.C.FACTOR is the complexity of the terrain between  
observer and target

RR is the apparent range to the target in kilometers

X.VELOCITY is the crossing velocity of the target

If the target is within 300 meters of the observer,  
detection is assumed to be essentially immediate and a time  
of one second is returned to event STEP.TIME. If the target  
is beyond 4000 meters of the observer, detection is assumed  
to be essentially infinite and a time of 99 is returned to  
event STEP.TIME.

#### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value  
of the observer.

ANGLE - A real variable containing the angle in radians  
between the observer's primary direction of search and the  
target.

AT - A real variable equivalent to  $1/2 \pi$ .

DD - A real variable used as a correction factor to  
calculate the apparent range to the target.

DET.TIME - A real variable containing the time to  
detect a given target.



LAMBDA - A real variable containing the value of the detection rate.

AREA - A real variable containing the observer's search area in degrees.

B - An integer variable containing the pointer value of the target vehicle.

BT - A real variable containing the value  $3/8\pi$ .

DENOM - A real variable containing the denominator of the detection rate equation.

P.SUB.X - A real variable containing a value representing the probability an observer is looking in a 30 degree portion of his search sector.

PER.FULL.EXPO - Percent of the target that is exposed (value returned from routine PERCENT).

RR - A real variable representing the angle from the observer to the target.

TGT.ELEMENT - A real variable representing the angle from the observer to the target.

X.VELOCITY - A real variable containing the crossing velocity of the target vehicle.

MT - A real variable containing the value  $6/\pi$ .



PCT.VIS - A real variable valued between 0 and 1 which represents the percentage of the target which is visible to the observer.

R - A real variable containing the range to the target in meters passed into routine CARDIO from event STEP.TIME.

T.C.FACTOR - A real variable representing the complexity of the terrain between the observer and target. Value is obtained by routine CARDIO by calling routine TER.COMPLEXITY.

X - A real variable containing the value of a uniform random variable between 0 and 1 passed into routine CARDIO from event STEP.TIME.

ZL - A real variable containing the constant .000001 used to prevent division by zero in the routine.

The coding for CARDIO is show below, followed by a brief explanation:

```
1  ROUTINE CARDIO(A,B,R,PCT.VIS,X)  YIELDING DET.TIME
2  DEFINE R,PCT.VIS,AND X AS REAL VARIABLES
3  DEFINE AREA AS A REAL VARIABLE
4  DEFINE A AND B AS INTEGER VARIABLES
5  IF COLOR(A) EQ RED
6      LET AREA=R.AREA
7  ALWAYS
```



```

8  IF COLOR(A) EQ BLUE
9      LET AREA=B.AREA
10 ALWAYS
11 IF R LE 300.0 LET DET.TIME=1.0
12 RETURN
13 ELSE
14 IF R GT 4000.0 LET DET.TIME=99.0
15 RETURN
16 ELSE
17 LET ZL=.000001
18 LET DD = PCT.VIS
19 IF DD LE 0. LET DD=ZL ALWAYS LET RR=(R/DD)/1000.
20 LET TGT.ELEMENT=ARCTAN.F ((Y.CURRENT(B)-Y.CURRENT
(A)), (X.CURRENT(B)-
21 X.CURRENT(A)))
22 IF AREA EQ 360.
23 GO TO FULL.CARDIOID
24 ELSE
25 LET P.SUB.K = 30./AREA
26 GO TO CONTINUE
27 'FULL.CARDIOID'
28 LET ANGLE=ABS.F(TGT.ELEMENT-PRI.DIR(A))

```





```

29  LET MT=6./PI.C
30  LET BT=3./(8.*PI.C)
31  LET AT=1./(2.*PI.C)
32  LET P.SUB.K=(BT/MT)+AT*(SIN.F(ANGLE+(1/MT))-SIN.F
(ANGLE))
33      IF P.SUB.K LT 0.
34      LET P.SUB.K=0
35  ALWAYS
36  'CONTINUE'
37  LET X.VELOCITY=ABS.F(SPD(B)*SIN.F(TGT.ELEMENT-DIR.
OF.MVMT(B)))
38  CALL TER.COMPLEXITY(X.CURRENT(A),Y.CURRENT(A),
X.CURRENT(B),Y.CURRENT(B))
39      YIELDING T.C.FACTOR
40  LET DENOM=1.453+T.C.FACTOR*(.5978+2.188*(RR**2)-
.5038*X.VELOCITY)
41  IF DENOM LE ZL
42  LET DENOM=ZL
43  ALWAYS
44  LET LAMBDA= .003+1.088/DENOM
45  IF LAMBDA LE 0.0 LET DET.TIME=0.0 RETURN ELSE
46  IF SPD(A) GT 0.

```



```

47 LET LAMBDA=LAMBDA/2
48 ALWAYS
49 CALL PERCENT(A,B) YIELDING PER.FULL.EXPO
50 LET LAMBDA=LAMBDA*PER.FULL.EXPO*P.SUB.K
51 IF LAMBDA LE 0.
52 LET LAMBDA=ZL
53 ALWAYS
54 LET DET.TIME=LOG.E.F(1.-X)/(-LAMBDA)
55 RETURN
56 END

```

Lines 1-4 define the routine and local variables.

Lines 5-10 assign appropriate search area to the observer based on user input from the MAIN program.

Lines 11-16 check range to the target versus upper and lower threshold values, and returns appropriate DET.TIME if threshold values are exceeded.

Line 17 sets value of ZL to prevent division by zero.

Line 18-19 calculate apparent range to the target.

Line 20 calculates angle between observer and target.

Lines 21-23 check to see if user has specified use of cardiod distribution and if so transfer to 'FULL.CARDIOD' label.



Lines 24-25 set value of P.SUB.K.

Lines 27-35 calculate value of P.SUB.K using the cardiod distribution.

Line 37 calculates crossing velocity of the target.

Lines 38-39 call routine TER.COMPLEXITY which returns with the value of T.C.FACTOR.

Lines 40-43 calculates the value of the denominator of the detection rate equation.

Lines 44-45 calculate the initial value of the detection rate. If the detection rate is less than or equal to 0, a time of 0.0 is returned, indicating immediate detection, to event STEP.TIME.

Lines 46-48 check to see if the observer is moving; if so, the detection rate is halved.

Line 49 calls routine PERCENT which returns with the value of PER.FULL.EXPO.

Lines 50-53 calculate final value of detection rate using P.SUB.K, PER.FULL.EXPO, and initial LAMBDA.

Line 54 calculates detection time.

Line 55 returns control to the calling event.



## S. ROUTINE PERCENT

Routine PERCENT is a dummy routine called by routine CARDIO yielding the real variable PER.FULL.EXPO.

PER.FULL.EXPO is a real variable which indicates the percentage of the movement trace of the target where the target is fully exposed (not concealed or covered), and is an integral part of the detection rate calculation in routine CARDIO.

Routine PERCENT in its present form always returns a value of 1.0 for PER.FULL.EXPO. Upon availability of micro-terrain data, this routine will return a real value between 0.0 and 1.0 to routine CARDIO by accessing the micro-terrain data.

### Local Variables

The following are local variables of this routine:

PER.FULL.EXPO - A real variable indicating the percentage of the target's movement trace that the target is fully exposed.

X - An integer variable containing the pointer value of the observer.

Y - An integer variable containing the pointer value of the target.





The coding for PERCENT is shown below, followed by a brief explanation:

```
1  ROUTINE FOR PERCENT GIVEN X AND Y YIELDING PER.FULL.EXPO
2  LET PER.FULL.EXPO=1
3  RETURN
4  END
```

Line 1 defines the routine and variables passed from routine CARDIO.

Line 2 defines the value of PER.FULL.EXPO to be 1.0.

Lines 3-4 return control to the calling routine or event.

T. ROUTINE TER.COMPLEXITY

#### Description

Routine TER.COMPLEXITY is a dummy routine called by routine CARDIO yielding the real variable T.C.FACTOR.

T.C.FACTOR is a real variable which indicates the complexity of the terrain between the observer and the target, and is an integral part of the detection rate calculations in routine CARDIO.

Routine TER.COMPLEXITY in its present form always returns a value of 1.0 for T.C.FACTOR. Upon availability



of micro-terrain data this routine will return a value between 1.0 and 7.0 to routine CARDIO by accessing the micro-terrain data.

### Local Variables

The following are local variables of this routine:

T.C.FACTOR - A real variable indicating the complexity of terrain between observer and target.

X - A real variable passed into TER.COMPLEXITY from routine CARDIO containing the current X coordinate of the observer.

Y - A real variable passed into TER.COMPLEXITY from routine CARDIO containing the current Y coordinate of the observer.

Z - Z real variable passed into TER.COMPLEXITY from routine CARDIO containing the current X coordinate of the target.

W - A real variable passed into TER.COMPLEXITY from routine CARDIO containing the current Y coordinate of the target.

The coding for TER.COMPLEXITY is shown below, followed by a brief explanation:



1 ROUTINE FOR TER.COMPLEXITY GIVEN X,Y,Z,W YIELDING

T.C.FACTOR

2 LET T.C.FACTOR=1.

3 RETURN

4 END

Line 1 defines the routine and variables passed into it from routine CARDIO.

Line 2 defines the value of T.C.FACTOR to be 1.0.

Lines 3-4 return control to the calling routine.

U. ROUTINE LIST.UPDATE

#### Description

Routine LIST.UPDATE is the means by which the list of detected targets for each weapon system in the simulation is kept current. The calling arguments are used to control the actions within the routine.

Routine LIST.UPDATE serves three distinct functions: addition of a target to a specified weapon system's target list, removal of a target from a specified weapon system's list and scheduling of event TARGET.SELECT.

Removal of a target from a list occurs when one of two conditions exist: either line of sight to the target no



longer exists or the target is considered "dead". If the target in question was not previously placed in the weapon system's target list, no action is taken in regard to updating the weapon system target list.

Addition of a target to a list occurs when the target is detected and line of sight exists to the target.

Either removal or addition of a target to a list may result in the scheduling of event TARGET.SELECT based on the value of the argument WHOCALLED passed into routine LIST.UPDATE by the calling event or routine a WHOCALLED value less than or equal to 1 will cause the routine to perform its function without event TARGET.SELECT being scheduled. A WHOCALLED argument of 2 or greater will cause event TARGET.SELECT to be scheduled prior to return to the calling event or routine.

#### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the weapon system whose list is to be updated.

B - An integer variable containing the pointer value of the target weapon system to be added or removed from the list.





COUNT - An integer variable set to equal the location of a particular target in a target list.

I - An integer variable used as a DO LOOP counter.

SIZE - An integer variable which indicates the dimension of a target list.

FLAG - An integer variable set to 1 if line of sight does not exist to a particular target or if the target in question is "dead", 0 otherwise.

LOSE - An integer variable set to 1 if line of sight exists to a target and to 0 if line of sight does not exist. The value of LOSE is passed to routine LIST.UPDATE by the calling event or routine.

WHOCALLED - An integer variable indicating the requirement for routine LIST.UPDATE to schedule event TARGET.SELECT.

The coding for LIST.UPDATE is shown below, followed by a brief explanation:

```
1  ROUTINE LIST.UPDATE(LOSE,A,B,WHOCALLED)
2  DEFINE I AS AN INTEGER VARIABLE
3  DEFINE A,B,LOSE,SIZE,COUNT,FLAG,AND WHOCALLED AS
INTEGER VARIABLES
4  LET LIST(*) = TARGET (NAME(A),1)  ' '  ACCESS
CORRECT LIST  ' '
```



```

5  IF LOSE EQ 0 OR ALIVE.DEAD(B) EQ 1
6      LET FLAG=1
7  REGARDLESS
8      LET SIZE = DIM.F(LIST(*))
9  FOR I = 1 TO SIZE, DO
10     IF B EQ LIST(I)
11         LET COUNT = I
12         GO TO OUT.OF.LOOP
13     ELSE
14         LOOP
15 IF FLAG EQ 1
16 LET LIST(*) = 0
17     RETURN
18 ELSE
19     IF LIST(1) EQ 0
20         LET LIST(1) = B
21         LET SIZE = 1
22 GO TO ALWAYS
23     ELSE
24         FOR I = 1 TO SIZE    LET TEMP.TGT(*) =
LIST(I)
25         LET TEMP.TGT(SIZE+ 1) = B

```



```

26  RELEASE LIST(*)

27      RESERVE LIST(*) AS SIZE + 1

28      LET TARGET(NAME(A),1) = LIST(*)

29      FOR I = 1 TO SIZE + 1  LET LIST(I) = TEMP.TGT(1)

30  'ALWAYS'

31      LET LIST(*) = 0

32  IF WHOCALLED LE 1 RETURN

33  ELSE

34  SCHEDULE A TARGET.SELECT(A) IN MIN.F(UNIFORM.F
(0.,SQRT.F(SIZE),2),

35  SQRT.F(5.0)) UNITS

36      RETURN

37  'OUT.OF.LOOP'

38  IF FLAG EQ 1

39      IF SIZE EQ 1 LET LIST(1) = 0

40          LET LIST(*) = 0

41      RETURN

42  ELSE

43      FOR I = 1 TO SIZE  LET TEMP.TGT(I) = LIST(I)

44  RELEASE LIST(*)

45      RESERVE LIST(*) AS SIZE - 1

46      LET TARGET (NAME(A),1) = LIST(*)

```



```

47      FOR I = 1 TO SIZE = 1, DO
48          IF I LT COUNT
49              LET LIST(I) = TEMP.TGT(I)
50      GO TO NEXT
51      ELSE
52          LET LIST(I) = TEMP.TGT(I+1)
53      'NEXT'
54      LOOP
55      REGARDLESS
56      LET LIST(*) = 0
57      IF WHOCALLED LE 1 OR FLAG EQ 1 RETURN ELSE
58      SCHEDULE A TARGET.SELECT(A) IN MIN.F(UNIFORM.F
(0.,SQRT.F(SIZE),2),
59      SQRT.F(5.0)) UNITS
60      RETURN
61      END

```

Lines 1-3 define the routine and local variables.

Lines 4 accesses the appropriate target list.

Lines 5-7 set FLAG to 1 if line of sight does not exist

or if the target in question is "dead".





Lines 8-18 search the accessed target list. If the target in question is in the list, COUNT is set equal to the target's location in the list and control is transferred to the 'OUT.OF.LOOP' label. If the target is not in the list, and FLAG=1, the list is released and control returned to the calling routine or event.

Lines 19-22 check to see whether the accessed list has any elements in it. If not, and all previous checks have been passed, the target in question is placed in the list and control transfers to the 'ALWAYS' label.

Lines 23-29 replace the accessed list with a new list which contains the target in question, and releases the core storage used by the old list for further use in the program.

Lines 30-36 check the WHOCALLED argument and schedule event TARGET.SELECT if appropriate, control is returned to the calling event or routine.

Lines 37-56 remove the appropriate target from the accessed target list and release the list.

Lines 57-59 check the WHOCALLED argument and schedule event TARGET.SELECT if appropriate.

Lines 60-61 return control to the calling event or routine.



## V. ROUTINE PROXIMITY.DETECT

### Description

Routine PROXIMITY.DETECT is called by event DETECT whenever a normal detection of a TANK occurs. This routine simulates the phenomenon of close vicinity detection. The rationale behind this routine is the fact that detection of an element on the battlefield causes detection of other elements within some relatively close, specified range. A single target selection is scheduled as a result of detecting a cluster of targets.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK effecting a near vicinity detection.

B - An integer variable containing the pointer value of the detected threat. Other elements close to this threat may be detected, if they meet certain close vicinity criteria (currently a square 150 meters on a side centered at the detected target).

WHOCALLED - An integer variable used to control the execution of a target selection in routine LIST.UPDATE.



A value of 0 prevents a target selection, while a value of 10 allows a target selection.

X.SAMPLE - A real variable containing the current X coordinate of the detected threat, B.

Y.SAMPLE - A real variable containing the current Y coordinate of the detected threat, B.

### Coding and Brief Explanation

The coding for routine PROXIMITY.DETECT is shown below, followed by a brief explanation.

```
1  ROUTINE PROXIMITY.DETECT(A,B)
2  DEFINE A AND B AS INTEGER VARIABLES
3  DEFINE X.SAMPLE AND Y.SAMPLE AS REAL VARIABLES
4  DEFINE WHOCALLED AS AN INTEGER VARIABLE
5  IF ALIVE.DEAD(B) EQ 1 RETURN ELSE
6  LET X.SAMPLE=X.CURRENT(B)
7  LET Y.SAMPLE=Y.CURRENT(B)
8  IF COLOR(A) EQ BLUE
9  FOR EACH TANK IN PLT.UNIT(PLT(B  ))
10                                     WITH ABS.F(X.CURRENT
TANK)-X.SAMPLE) LE 75.0
11      AND ABS.F(Y.CURRENT(TANK)-Y.SAMPLE) LE 75.0, DO
```



```

12  IF TANK EQ B LET WHOCALLED = 10 ALWAYS
13  CALL LIST.UPDATE(1,A,TANK,WHOCALLED)
14  LET WHOCALLED = 0
15      LOOP      JUMP AHEAD
16  ELSE
17  FOR EACH TANK IN PLT.UNIT(PLT(B  ))
18                                  WITH ABS.F(X.CURRENT
(TANK)-X.SAMPLE) LE 75.0
19      AND ABS.F(Y.CURRENT(TANK)-Y.SAMPLE) LE 75.0, DO
20  IF TANK EQ B LET WHOCALLED = 10 ALWAYS
21  CALL LIST.UPDATE(1,A,TANK,WHOCALLED)
22  LET WHOCALLED = 0
23  LOOP
24  HERE
25  RETURN
26  END

```

Lines 1-4 define the routine and local variables.

Line 5 insures that the currently detected threat,  
B, is still alive prior to proceeding.

Lines 6-7 place the X and Y coordinates of the currently  
detected threat in holding variables.





Line 8 accesses the BLUE section of this routine.

Lines 9-11 search B's platoon for TANKs within a 150 meter square centered on B.

Lines 12-14 test if the TANK meeting the distance criteria is in fact B. If so, routine LIST.UPDATE is accessed with a WHOCALLED value of 10. This insures a potential target selection based on the detection of B. If the TANK meeting the distance criteria is merely a member of B's platoon, routine LIST.UPDATE is accessed with a WHOCALLED value of 0 and no target selection is scheduled as a result of close vicinity detections. After searching the platoon, control is returned to event DETECT.

Line 16 accesses the RED portion of the routine.

Lines 17-25 are virtually identical to lines 9-15, but apply to RED weapon systems.

#### W. ROUTINE T72.TACTICS

##### Description

Routine T72.TACTICS is the tactical routine used to simulate platoon level fire control within the RED tank force. Routine T72.TACTICS is called by event TARGET.SELECT and returns to event TARGET.SELECT the integer variable ANSWER. If the value of ANSWER=1, the RED tank in question



will go thru the normal target selection process. An ANSWER of 0 indicates to event TARGET.SELECT that the tank in question has acquired a target designated by his platoon leader.

Routine T72.TACTICS sequences through several checks to determine if it is appropriate for the RED tank in question to have designated as his highest priority target his platoon leader's currently selected target. All four of the following conditions must be met for a platoon member to have his platoon leader's target designated as his own.

1. The platoon leader must be "alive".
2. Line of sight must exist between platoon leader and member.
3. The platoon leader must have a target selected.
4. The platoon member must have the proper ammunition type available.

If any of these four conditions are not met, ANSWER is set to 1, and control returned to the calling event.

#### Local Variables

The following are local variables of this routine:



A - An integer variable containing the pointer value of the platoon member.

ANSWER - An integer variable assigned a value of 1 if the vehicle is to go through a normal target select, and 0 if the tank has acquired his platoon leader's target.

LOSE - An integer variable indicating the existence of line of sight; 1 indicates line of sight exists, 0 indicates line of sight does not exist.

AIM - An integer variable returned to T72.TACTICS from routine COMMO.PASS.TARGET containing the pointer value of the platoon leader's currently selected target.

RESULT - An integer variable returned to T72.TACTICS by routine AMMO.CHECK indicating the availability of appropriate ammunition. If RESULT equals 0, the proper ammunition is not available; RESULT equals 1 otherwise.

The coding for T72.TACTICS is shown below, followed by a brief explanation:

```
1  ROUTINE T72.TACTICS(A)  YIELDING ANSWER
2  DEFINE A, ANSWER, AND RESULT AS INTEGER VARIABLES
3  DEFINE AIM AS AN INTEGER VARIABLE
4  DEFINE LOSE AS AN INTEGER VARIABLE
```



```

5 LET ANSWER = 0
6 IF PLTLDR(A) NE A AND COCDR(A) NE A
7 IF ALIVE.DEAD(PLTLDR(A)) EQ 1
8 FOR EACH TANK IN PLT.UNIT(PLT(A ))
9 LET PLTLDR(TANK) = TANK LET ANSWER = 1 RETURN ELSE
10 CALL LOC(A) CALL LOC(PLTLDR(A))
11 CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT
(PLTLDR(A)),HTTGT(PLTLDR(A)),
12 X.CURRENT(PLTLDR(A)),Y.CURRENT(PLTLDR(A)),Z.CURRENT
(PLTLDR(A)),HTTGT(PLTLDR(A)),
13 P.V(*)
14 LET PCT.VIS=P.V(1)
15 IF PCT.VIS GT CRITICAL.VALUE
16 LET LOSE=1 JUMP AHEAD ELSE LET LOSE=0 HERE
17 IF LOSE EQ 0 LET ANSWER= 1 RETURN ELSE GO TO COMMO
18 'COMMO' CALL COMMO.PASS.TGT(A) YIELDING AIM
19 IF AIM NE 0
20 CALL AMMO.CHECK(A,PROJO(PLTLDR(A))) YIELDING RESULT
21 IF RESULT EQ 0 LET ANSWER = 1 RETURN ELSE
22 LET FOE(A) = AIM LET PROJO(A) = PROJO(PLTLDR(A))
23 LET SCHED(A) = 1

```





```
24 SCHEDULE A FIRE(A,AIM) IN MAX.F(UNIFORM.F(10.,20.,3),  
UNIFORM.F(8.,16.,4)) UNITS  
  
25 LET CHECK.TIME(A) = TIME.A(FIRE) RETURN  
  
26 ELSE ALWAYS LET ANSWER=1 RETURN END
```

Lines 1-5 define the routine and local variables and set the initial value of ANSWER.

Line 6 checks to determine if the tank in question is a platoon leader or a company commander; if so, control is transferred to line 26, ANSWER is set to 1, and control is returned to the calling event.

Lines 8-9 check to see if the appropriate platoon leader is "dead". If so, each member of that particular platoon is made a "platoon leader". This causes platoon members whose platoon leader is destroyed to always go through the normal sequence of selecting a target from their own target lists.

Lines 10-17 update the location of the platoon leader and platoon member and determine if line of sight exists between the two. If line of sight does not exist, ANSWER is set to 1 and control is returned to event TARGET.SELECT.

Line 18 calls routine COMMO.PASS.TARGET and has returned the platoon leader's current FOE attribute (AIM).



Lines 19-21 determine if the platoon leader has a current FOE and checks to see if the platoon member has the appropriate ammunition available. If the proper ammunition is not available, ANSWER is set to 1, and control is returned to the calling event.

Lines 22-25 set the proper FOE, PROJ0, SCHED, and CHECK.TIME attributes on the platoon member and schedule the event FIRE to occur in the maximum of the lay and load time of the weapon system.

Line 26 returns control to the calling event.

#### X. ROUTINE COMMO.PASS.TGT

##### Description

Routine COMMO.PASS.TGT is used by routine T72.TACTICS for RED TANK fire control. In the current version of STAR, only weapons of type T72 use this routine. The selecting TANK, if not a platoon leader attempts to acquire as his FOE the FOE of his platoon leader. Line of sight must exist between the selecting tank and his platoon leader, the platoon leader must be alive, the potential target must be within the opening range of the platoon member and the platoon member must have a FOE. If any of these four conditions is not met, control is returned to routine



T72.TACTICS with AIM = 0. This directs T72.TACTICS to allow a normal target selection for the firer. If all conditions are met, AIM is set to the pointer value of the platoon leader's FOE and T72.TACTICS allows an attempted engagement of this FOE.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK attempting to acquire the FOE of his platoon leader.

BAIM - An integer variable containing the pointer value of the platoon leader's FOE.

AIM - An integer variable which assumes the value 0 if any of the four conditions mentioned in the description above are not met. AIM assumes the value of BAIM if all conditions are met.

LOSE - An integer variable which assumes the value 1 if line of sight exists between A and his platoon leader. LOSE assumes the value 0 if line of sight does not exist.

R - A real variable which represents the range in meters from A to the platoon leader's FOE.



## Coding and Brief Explanation

The coding for routine COMMO.PASS.TGT is shown below,  
followed by a brief explanation:

```
1  ROUTINE COMMO.PASS.TGT(A) YIELDING AIM
2  DEFINE A, AIM, BAIM, AND LOSE AS INTEGER VARIABLES
3  DEFINE R AS A REAL VARIABLE
4  LET BAIM=FOE(PLTLDR(A))
5  IF BAIM EQ 0
6  LET AIM=0
7  RETURN
8  ELSE
9  IF ALIVE.DEAD(BAIM) EQ 1 LET AIM=0 RETURN ELSE
10 CALL LOC(BAIM)
11 CALL LOS GIVEN X.CURRENT(A),Y.CURRENT(A),Z.CURRENT
(A),HTO(A),X.CURRENT(BAIM),
12 Y.CURRENT(BAIM),Z.CURRENT(BAIM),HTTGT(BAIM),P.V(*)
13 LET PCT.VIS=P.V(1)
14 IF PCT.VIS GT CRITICAL.VALUE
15 LET LOSE=1 JUMP AHEAD ELSE LET LOSE=0 HERE
16 IF LOSE EQ 0
17 LET AIM=0
18 RETURN
```





```

19  ELSE

20  CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT(BAIM),
Y.CURRENT(BAIM))

21          YIELDING R

22  IF R GT OP.RNG(A)

23  LET AIM=0

24  RETURN

25  ELSE

26  LET AIM=BAIM

27  RETURN

28  END

```

Lines 1-3 define the routine and local variables.

Line 4 assigns to BAIM the pointer value of the platoon leader's FOE.

Lines 5-8 test the platoon leader's FOE. If the platoon leader has no FOE, AIM is set to 0 and control is returned to routine T72.TACTICS.

Line 9 insures that BAIM is still alive before proceeding. If not, AIM is set to 0 and control returns to routine T72.TACTICS.

Line 10 updates the current X, Y, and Z coordinates.



Lines 11-15 check line of sight between the observer, A, and his potential target, BAIM. If the percentage of the target visible to the observer is greater than a user defined threshold, line of sight exists.

Lines 16-18 return AIM with a value of 0 to routine T72.TACTICS if line of sight does not exist.

Lines 19-21 calculate the range in meters between the observer and the target.

Lines 22-24 return AIM with a value of 0 to routine T72.TACTICS if the potential target is outside the observer's maximum effective range.

Lines 25-27 return AIM with a value equal to BAIM to routine T72.TACTICS if both the line of sight and range tests are satisfied.

Y. ROUTINE BMP.TACTICS

#### Description

Routine BMP.TACTICS is used by event TARGET.SELECT to determine if a BMP's currently accessed threat is being engaged by another company member. If so, an ANSWER = 1 is returned to event TARGET.SELECT and the threat in question



is no longer considered a potential target during the current TARGET.SELECT.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the BMP which is attempting to select a target.

B - An integer variable containing the pointer value of the currently accessed threat in the BMP's detected list.

ANSWER - An integer variable which is assigned a value of 1 if A's potential target, B, is being engaged by another company member.

### Coding and Brief Explanation

The coding for routine BMP.TACTICS is shown below, followed by a brief explanation:

```
1  ROUTINE BMP.TACTICS(A,B)  YIELDING ANSWER
2  DEFINE A, B, AND ANSWER AS INTEGER VARIABLES
3  LET ANSWER = 0
4  FOR EACH TANK IN COMP.UNIT(CO(A  )), DO
5  IF B EQ FOE(TANK) LET ANSWER = 1 RETURN
6  ELSE LOOP RETURN END
```

Lines 1-2 define the routine and local variables.

Line 3 sets the default value of ANSWER to 0.



Lines 4-6 search other company members and determine if anyone is engaging A's potential target. The appropriate value for ANSWER is set and control returns to event TARGET.SELECT.

## Z. ROUTINE XML.TACTICS

### Description

Routine XML.TACTICS is used by event TARGET.SELECT to determine if an XML's currently accessed threat is being engaged by another platoon member. If this is the case, an ANSWER = 1 is returned to TARGET.SELECT and the threat in question is no longer considered a potential target during the current target selection event.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK which is attempting to select a target.

B - An integer variable containing the pointer value of the currently accessed threat in the XML's detected list.

ANSWER - An integer variable which is assigned a value of 1 if A's potential target, B, is being engaged by another platoon member.





## Coding and Brief Explanation

The coding for routine XM1.TACTICS is shown below, followed by brief explanation:

```
1  ROUTINE XM1.TACTICS(A,B) YIELDING ANSWER
2  DEFINE A, B, AND ANSWER AS INTEGER VARIABLES
3  LET ANSWER = 0
4  FOR EACH TANK IN PLT.UNIT(PLT(A )), DO
5  IF B EQ FOE(TANK) LET ANSWER = 1 RETURN
6  ELSE LOOP RETURN END
```

Lines 1-2 define the routine and local variables.

Line 3 sets the default value of ANSWER to 0.

Lines 4-6 search other platoon members and determine if anyone in the platoon is engaging A's potential target. The appropriate value of ANSWER is set and control is returned to event TARGET.SELECT.

AA. ROUTINE IFV.TACTICS

## Description

Routine IFV.TACTICS is used by event TARGET.SELECT to determine if an IFV's currently accessed threat is being engaged by another platoon member. If this is the case, an



ANSWER = 1 is returned to TARGET.SELECT and the threat in question is no longer considered a potential target during the current target selection event.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the IFV which is attempting to select a target.

B - An integer variable containing the pointer value of the currently accessed threat in the IFV's detected list.

ANSWER - An integer variable which is assigned a value of 1 if A's potential target, B, is being engaged by another platoon member.

### Coding and Brief Explanation

The coding for routine IFV.TACTICS is shown below, followed by a brief explanation:

```
1  ROUTINE IFV.TACTICS(A,B) YIELDING ANSWER
2  DEFINE A, B, AND ANSWER AS INTEGER VARIABLES
3  LET ANSWER = 0
4  FOR EACH TANK IN PLT.UNIT(PLT(A )), DO
5  IF B EQ FOE(TANK) LET ANSWER = 1 RETURN
6  ELSE LOOP RETURN END
```



Lines 1-2 define the routine and local variables.

Line 3 sets the default value of ANSWER to 0.

Lines 4-6 search other platoon members and determine if anyone is engaging A's potential target. Control is then returned to event TARGET.SELECT.

#### BB. ROUTINE ITV.TACTICS

##### Description

Routine ITV.TACTICS is identical to routine IFV.TACTICS. The coding is shown below. A description, list of local variables, and brief explanation of the coding is given in routine IFV.TACTICS.

```
1  ROUTINE ITV.TACTICS(A,B) YIELDING ANSWER
2  DEFINE A, B, AND ANSWER AS INTEGER VARIABLES
3  LET ANSWER = 0
4  FOR EACH TANK IN PLT.UNIT(PLT(A )), DO
5  IF B EQ FOE(TANK) LET ANSWER = 1 RETURN
6  ELSE LOOP RETURN END
```

#### CC. ROUTINE PRIORITY.AND.ROUND.SELECT

##### Description

Routine PRIORITY.AND.ROUND.SELECT is used by event TARGET.SELECT to assign a priority to the threat currently



being accessed and to specify the type of ammunition to be used against this threat. As previously discussed, these priorities and ammunition selections are provided in the danger state arrays, DS1 and DS2 (see Tables III and IV in chapter V). Danger state arrays provided as part of the basic model are currently limited to five BLUE weapon types and three RED weapon types, with a maximum of four ammunition types each. Weapon system and ammunition codes are shown in table I.

#### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK for which a target priority and an ammunition selection is required.

B - An integer variable containing the pointer value of the currently accessed threat in the selecting TANK's.

ANSWER - The returned argument from routine AMMO.CHECK.

An ANSWER = 1 indicates that the required ammunition is available. An ANSWER = 0 indicates the converse.

I - An integer counter which accesses the appropriate row of the danger state array.





J - An Integer counter which accesses the appropriate column of the danger state array.

THRESHOLD - An integer constant used as an upper bound for P.

P - An integer variable which assumes the priority value in the currently accessed row and column of the danger state array.

RND - The preferred ammunition type associated with the target for which a priority has been assessed.

#### Coding and Brief Explanation

The coding for routine PRIORITY.AND.ROUND.SELECT is shown below, followed by a brief explanation:

```
1  ROUTINE PRIORITY.AND.ROUND.SELECT(A,B) YIELDING P,  
AND RND  
2  DEFINE A,B,P,RND,I,J,ANSWER,AND THRESHOLD AS INTEGER  
VARIABLES  
3  LET THRESHOLD=99  
4  IF COLOR(A) EQ BLUE  
5  LET I=WPN.TYPE(A)  
6  IF I EQ 1 LET I=2  
7  ALWAYS LET I=I-1  
8  GO TO I0,I3,I6,I9,I12 PER I
```



```

9  'I0'  LET I=0  GO TO BANDS
10 'I3'  LET I=3  GO TO BANDS
11 'I6'  LET I=6  GO TO BANDS
12 'I9'  LET I=9  GO TO BANDS
13 'I12' LET I=12  GO TO BANDS
14 'BANDS' LET I=I+MIN.F(TRUNC.F(RANGE(A)/1000),2)
15 GO TO J1,J9,J17 PER WPN.TYPE(B)-6
16 'J1'  LET J=1  GO TO START
17 'J9'  LET J=9  GO TO START
18 'J17' LET J=17  GO TO START
19 'START'
20 LET P=DS1(I,J)
21 IF P GE THRESHOLD RETURN ELSE
22 LET RND=DS1(I,J+1)
23 CALL AMMO.CHECK(A,RND) YIELDING ANSWER
24 IF ANSWER EQ 0 LET J=J+2 GO TO START
25 ELSE RETURN
26 ELSE
27 LET I=WPN.TYPE(A)-6
28 GO TO I10,I13,I16 PER I
29 'I10' LET I=0 GO TO SBANDS
30 'I13' LET I=3 GO TO SBANDS

```



```

31 'II6' LET I=6 GO TO SBANDS
32 'SBANDS' LET I=I+1+MIN.F(TRUNC.F(RANGE(A)/1000),2)
33 LET J=WPN.TYPE(B)
34 IF J=1 LET J=2
35 ALWAYS LET J=J-1
36 GO TO JJ1,JJ9,JJ17,JJ25,JJ33 PER J
37 'JJ1' LET J=1 GO TO SSTART
38 'JJ9' LET J=9 GO TO SSTART
39 'JJ17' LET J=17 GO TO SSTART
40 'JJ25' LET J=25 GO TO SSTART
41 'JJ33' LET J=33 GO TO SSTART
42 'SSTART'
43 LET P=DS2(I,J)
44 IF P GE THRESHOLD RETURN ELSE
45 LET RND=DS2(I,J+1)
46 CALL AMMO.CHECK(A,RND) YIELDING ANSWER
47 IF ANSWER EQ 0 LET J=J+2 GO TO SSTART
48 ELSE RETURN
49 END

```

Lines 1-2 define the routine and local variables.

Line 3 sets the value of THRESHOLD to 99.

Line 4 accesses the BLUE portion of the routine.



Lines 5-7 calculate the firer's weapon type to insure that it reflects one of the available weapon types in the danger state array.

Lines 8-13 reset the row index, I, based on the weapon type of the firer, A, and transfer control to label 'BANDS'.

Line 14 adds a minimum of 1 and a maximum of 3 to the current value of I. This accesses the proper row of the danger state array in accordance with the weapon type of the firer and the range band of the target.

Lines 15-19 set an initial value for the column index, J, based on the weapon type of the target.

Lines 20-21 calculate the target priority within the given rangeband. If the priority equals or exceeds the value of THRESHOLD, the target cannot be engaged and control returns to event TARGET.SELECT.

Line 22 returns the type of ammunition required to engage the target.

Lines 23-25 verify that the required ammunition is available. If not the program transfers to line 19. If the ammunition is available, the priority, P, and ammunition type, RND, are returned to event TARGET.SELECT.

Line 26 accesses the RED portion of the routine.





Lines 28-31 set an initial value for the row index, I, based on the weapon type of the firer, and transfer control to label 'SBANDS'.

Line 32 adds a minimum of 1 and a maximum of 3 to the current value of I. This accesses the proper row of the danger state array in accordance with the weapon type of the firer and rangeband of the target.

Lines 33-41 set an initial value for the column index, J, based on the weapon type of the target.

Lines 42-44 calculate the target priority within the given rangeband. If the priority equals or exceeds the value of THRESHOLD, the target cannot be engaged and a return to event TARGET.SELECT is effected.

Line 45 returns the type of ammunition required to engage the target.

Lines 46-48 verify that the required ammunition is available. If not the program transfers to line 32. If the ammunition is available, the priority, P, and ammunition type, RND, are returned to event TARGET.SELECT.

DD. ROUTINE AMMO.CHECK

#### Description

Routine AMMO.CHECK is used by three other STAR routines:



T72.TACTICS, PRIORITY, AND ROUND.SELECT, AND WE.MISS. In all cases a return of ANSWER = 0 from AMMO.CHECK indicates that the ammunition of the type specified is not available. The converse is true for ANSWER = 1.

If the required ammunition is available in T72.TACTICS, the TANK is allowed to select as his FOE the FOE of his platoon leader. The TANK then schedules a FIRE on this FOE. If the required ammunition is not available, the TANK initiates a normal target selection by returning to event TARGET.SELECT.

Similarly, in routine PRIORITY.AND.ROUND.SELECT, a lack of the required ammunition will cause a further search of the danger state array.

Finally, a lack of the required ammunition in routine WE.MISS initiates a target selection as opposed to firing again on the same target. The lack of ammunition may cause another target to assume a higher priority as determined from the danger state array.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of TANK for which ammunition is being checked.



RND - An integer variable containing the numeric type of ammunition being checked.

ANSWER - An integer variable which takes on the value 1 if ammunition of the type corresponding to RND is available, and the value 0 if this type of ammunition is not available.

### Coding and Brief Explanation

The coding for ROUTINE AMMO.CHECK is shown below, followed by a brief explanation:

```
1  ROUTINE AMMO.CHECK(A,RND) YIELDING ANSWER
2  DEFINE A,RND,AND ANSWER AS INTEGER VARIABLES
3  LET ANSWER=1
4  GO TO AP,HE,AW1,AW2 PER RND
5  'AP' IF AP.TOW(A) EQ 0 LET ANSWER=0 ALWAYS RETURN
6  'HE' IF HE.DRAG(A) EQ 0 LET ANSWER=0 ALWAYS RETURN
7  'AW1' IF AW1.OR.MSL3(A) EQ 0 LET ANSWER=0 ALWAYS
RETURN
8  'AW2' IF AW2.OR.ADM(A) EQ 0 LET ANSWER=0 ALWAYS
RETURN
9  END
```

Lines 1-3 define the routine, local variables, and set the variable ANSWER to a default value of 1.



Line 4 directs a transfer to one of four labels by means of a computed go to statement. RND may take on the values 1, 2, 3, or 4.

Lines 5-8 check the appropriate ammunition count.

EE. ROUTINE STOP.TO.FIRE

#### Description

Routine STOP.TO.FIRE is used by events FIRE and IMPACT to halt and restart missile firing weapon systems at appropriate times. In general, missile firing systems will stop prior to firing and begin movement after assessing results of their current round. If other than missile firing systems are required to use these tactics, the IF statement prior to CALL STOP.TO.FIRE in events FIRE and IMPACT must be changed to test for the added weapon system types.

#### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK for which a stop or start is required.

STOPCOUNT - An integer variable which assumes the value 1 if the routine is called from event FIRE, or the value 2 if the routine is called from event IMPACT.





## Coding and Brief Explanation

The coding for routine STOP.TO.FIRE is shown below, followed by a brief explanation:

```
1  ROUTINE STOP.TO.FIRE(A,STOPCOUNT)
2  DEFINE A AND STOPCOUNT AS INTEGER VARIABLES
3  IF PROJ0(A) EQ 3 RETURN ELSE
4  GO TO X1,X2 PER STOPCOUNT
5  'X1'  LET SPD(A)=0.0
6  LET T.SPD(A)=TIME.V
7  RETURN
8  'X2'  LET SPD(A)=7.0
9  LET T.SPD(A)=TIME.V
10 LET SECOND.SHOT(A)=0
11 RETURN
12 END
```

Lines 1-2 define the routine and local variables.

Line 3 insures that control is returned to the calling event if anything other than a missile (ammunition types 1 or 2) is being fired.

Line 4 transfers control to label X1 (a stop called from event FIRE) if STOPCOUNT is 1 or to label X2 (a start called from event IMPACT) if STOPCOUNT is 2.



Lines 5-7 set the firer's speed to zero, record the time that the speed was set to zero, and return control to event FIRE.

Lines 8-11 set the firer's speed to desired unit speed, record the time that this speed was set, reset the second shot counter attribute to zero, and return control to event IMPACT.

FF. ROUTINE SET.MUZZLE.VEL

#### Description

Routine SET.MUZZLE.VEL is used by event FIRE to obtain the velocity of the type of ammunition being fired. The range to the target divided by this velocity yields the time of flight of the round. This time is used by event FIRE to schedule event IMPACT. As discussed in the PREAMBLE section, the M1, M2, M3, and M4 attributes for muzzle velocities are associated with projectile or ammunition types 1, 2, 3, or 4.

#### Local Variable

The following is a local variable of this routine:

A - An integer variable containing the pointer variable of the weapon system for which a muzzle velocity is required.



### Coding and Brief Explanation

The coding for routine SET.MUZZLE.VEL is shown below. As discussed previously, PROJ0(A) is an integer variable which assumes values 1 through 4 depending on the ammunition type being fired. This keys the computed go to statement to the appropriate label. The remainder of the code is self explanatory.

```
1  ROUTINE SET.MUZZLE.VEL(A)
2  DEFINE A AS AN INTEGER VARIABLE
3  GO TO AP, HE, AW1, AW2 PER PROJ0(A)
4  'AP'  LET MZL.VEL(A) = M1(A) RETURN
5  'HE'  LET MZL.VEL(A) = M2(A) RETURN
6  'AW1' LET MZL.VEL(A) = M3(A) RETURN
7  'AW2' LET MZL.VEL(A) = M4(A) RETURN
8  END
```

GG. ROUTINE DECREMENT.AMMO

### Description

Routine DECREMENT.AMMO is used by event IMPACT to reflect the expenditure of ammunition. Any of four ammunition categories defined by the user may be decremented.



## Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK for which ammunition is being decremented.

RND - An integer variable containing the numeric type of ammunition being decremented.

## Coding and Brief Explanation

The coding for routine DECREMENT.AMMO is shown below, followed by a brief explanation:

```
1  ROUTINE DECREMENT.AMMO(A,RND)
2  DEFINE A AND RND AS INTEGER VARIABLES
3  GO TO AP,HE,AW1,AW2 PER RND
4  'AP' LET AP.TOW(A)=AP.TOW(A)-1 RETURN
5  'HE' LET HE.DRAG(A)=HE.DRAG(A)-1 RETURN
6  'AW1' LET AW1.OR.MSL3(A)=AW1.OR.MSL3(A)-1 RETURN
7  'AW2' LET AW2.OR.ADM(A)=AW2.OR.ADM(A)-1 RETURN
8  END
```

Lines 1-2 define the routine and local variables.

Line 3 directs a transfer to one of four labels by means of a computer go to statement. RND may take on the values 1, 2, 3, or 4.





Lines 4-7 decrement the appropriate ammunition type by subtracting 1 from a TANK's ammunition type attribute. Control is returned to event IMPACT.

#### HH. ROUTINE COMPUTE

##### Description

Routine COMPUTE is used by event IMPACT to assign a probability of hit for each weapon system and ammunition type. The values generated by routine COMPUTE are gross approximations and are used solely to provide values which will exercise the model. Users should supply their own hit probability routines. Recall that in current version of STAR, a hit is synonymous with a catastrophic kill.

##### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK which has fired.

ID - An integer variable containing the pointer value of the target TANK.

PCT.VIS - A real variable which may take on continuous values between 0 and 1. Note that a PCT.VIS of less than 1 reduces the computed probability of hit.



## Coding and Brief Explanation

The coding for routine COMPUTE is shown below, followed by a brief explanation:

```
1  ROUTINE COMPUTE(A,ID,PCT.VIS)
2  DEFINE A AND ID AS INTEGER VARIABLES
3  DEFINE PCT.VIS AND R AS REAL VARIABLES
4  CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT(ID),
Y.CURRENT(ID)) YIELDING R
5  LET RANGE(A) = R
6  GO TO XML,XM1,IFV,ITV,DIVAD,DRAGON,T72,BMP,ZSU PER
WPN.TYPE(A)
7  'XML' 'T72' LET PH(A)=1-RANGE(A)/3000. GO TO ZSU
8  'IFV' 'ITV' 'DRAGON' LET PH(A) = 1 - .15 * RANGE(A) /
3000.0 GO TO ZSU
9  'BMP' LET PH(A) = 1 - .25 * RANGE(A) / 3000.0 GO TO
ZSU
10 'ZSU' 'DIVAD' IF PROJ0(A)=3 LET PH(A)=.3 ALWAYS LET
PH(A)=PCT.VIS*PH(A) RETURN
11 END
```

Lines 1-3 define the routine and local variables.

Line 4 calculates the current range to the target.



Line 5 sets the RANGE attribute of the firer to the current range calculated above.

Line 6 directs a transfer to one of 9 labels by means of a computed go to statement.

Lines 7-10 compute the appropriate probability of hit; control is then returned to event IMPACT.

## II. ROUTINE TALLY.HIT.STATE

### Description

Routine TALLY.HIT.STATE is used by event IMPACT to account for each type of kill sustained by a weapon system. The following categories are available: ND.HIT, M.KILL, F.KILL, MF.KILL, and K.KILL. These categories are weapon system attributes and are defined in the discussion of the PREAMBLE. In addition, this routine accumulates the total number of hits sustained and the total number of rounds fired at the weapon system (hits plus misses). Currently, only the 'K.KILL' and 'MISS' sections of this routine are used.

### Local Variables

The following are local variables of this routine:

TANK - An integer variable containing the pointer value of the weapon system for which a hit category is being updated.



DAMAGE.NUM - An integer variable which takes on the values 1 through 6 depending on the type of hit sustained.

#### Coding and Brief Explanation

The coding for routine TALLY.HIT.STATE is shown below, followed by a brief explanation:

```
1  ROUTINE TALLY.HIT.STATE(TANK,DAMAGE.NUM)
2  DEFINE TANK AND DAMAGE.NUM AS INTEGER VARIABLES
3  GO TO NO.DAMAGE,M.KILL,F.KILL,MF.KILL,K.KILL,MISS
PER DAMAGE.NUM
4  'NO.DAMAGE'
5  LET ND.HIT(TANK)=MD.HIT(TANK)+1
6  LET NUM.HIT(TANK)=NUM.HIT(TANK)+1
7  LET FIRED.AT(TANK)=FIRED.AT(TANK)+1
8  'M.KILL'
9  LET M.HIT(TANK)=M.HIT(TANK)+1
10 LET NUM.HIT(TANK)=NUM.HIT(TANK)+1
11 LET FIRED.AT(TANK)=FIRED.AT(TANK)+1
12 RETURN
13 'F.KILL'
14 LET F.HIT(TANK)=F.HIT(TANK)+1
15 LET NUM.HIT(TANK)=NUM.HIT(TANK)+1
16 LET FIRED.AT(TANK)=FIRED.AT(TANK)+1
```





```

17  RETURN

18  'MF.KILL'

19  LET MF.HIT(TANK)=MF.HIT(TANK)+1

20  LET NUM.HIT(TANK)=NUM.HIT(TANK)+1

21  LET FIRED.AT(TANK)=FIRED.AT(TANK)+1

22  RETURN

23  'K.KILL'

24  LET K.HIT(TANK)=K.HIT(TANK)+1

25  LET NUM.HIT(TANK)=NUM.HIT(TANK)+1

26  LET FIRED.AT(TANK)=FIRED.AT(TANK)+1

27  IF COLOR(TANK) EQ BLUE AND M.BLUE.ALIVE(TANK) EQ 1
REMOVE TANK FROM BLUE.ALIVE

28  REMOVE TANK FROM PLT.UNIT(PLT(TANK))

29  REMOVE TANK FROM COMP.UNIT(CO(TANK))

30      RETURN ELSE

31  IF M.RED.ALIVE(TANK) EQ 1 REMOVE TANK FROM RED.ALIVE

32  REMOVE TANK FROM PLT.UNIT(PLT(TANK)) REMOVE TANK FROM
COMP.UNIT(CO(TANK))

33  ALWAYS RETURN

34  'MISS'

35  LET FIRED.AT(TANK)=FIRED.AT(TANK)+1

36  RETURN

37  END

```



Lines 1-2 define the routine and local variables.

Line 3 uses a computed go to statement to access the appropriate hit category.

Lines 4-7 increment by one the number of no damage hits sustained, the total number of hits sustained, and the total number of rounds fired at the weapon system. Control is then returned to event IMPACT.

Lines 8-12 are similar to those above except that the number of mobility hits sustained is incremented by one.

Lines 13-17 are similar to those above except that the number of firepower hits sustained is incremented by one.

Lines 18-22 are similar to those above except that the number of mobility and firepower hits are incremented by one.

Lines 23-26 are similar to those above except that the number of catastrophic kills is incremented by one. Control is not returned to event IMPACT until set manipulation is accomplished by the next 7 lines.

Lines 27-30 insure that the TANK is BLUE and that he has not already been removed from the set of blue, alive tanks. If these conditions are met the TANK is removed from sets



## Coding and Brief Explanation

The coding for routine WE.MISS is shown below, followed by a brief explanation:

```
1  ROUTINE WE.MISS(A)
2  DEFINE A AND ANSWER AS INTEGER VARIABLES  DEFINE R
AS A REAL VARIABLE
3  LET MISSHOT(A) = MISSSHOT(A) + 1
4  GO TO XML,XM1,IFV,ITV,DIVAD,DRAGON,T72,BMP,ZSU PER
WPN.TYPE(A)
5  'XML'      'DIVAD'
6  IF MISSSHOT(A) EQ 2 OR HITSHOT(A) EQ 2
7  'MOVE'
8  LET HITSHOT(A) = 0 LET MISSSHOT(A) = 0 LET FOE(A) = 0
9  SCHEDULE A HIDE(A,1) NOW
10 RETURN ELSE
11 CALL AMMO.CHECK(A,PROJO(A)) YIELDING ANSWER
12 IF ANSWER EQ 0 GO TO ZSU
13 ELSE GO TO FIRE
14 'IFV'
15 'ITV'
16 'DRAGON'
17 IF HITSHOT(A) + MISSSHOT(A) GE 2
```



```

18 GO TO MOVE ELSE GO TO T72
19 'T72'
20 'BMP'
21 'ZSU'
22 LET FOE(A) = 0 SCHEDULE A TARGET.SELECT(A) NOW
23 RETURN
24 'FIRE'
25 CALL DIST(X.CURRENT(A),Y.CURRENT(A),X.CURRENT(FOE)),
Y.CURRENT(FOE(A)))
26 YIELDING R
27 LET RANGE(A) = R LET SCHED(A) = 1
28 SCHEDULE A FIRE(A,FOE(A)) IN UNIFORM.F(4.,10.,8) UNITS
29 LET CHECK.TIME(A) = TIME.A(FIRE)
30 RETURN END

```

Lines 1-2 define the routine and local variables.

Line 3 increments by one the MISSSHOT attribute of the firer.

Line 4 directs a transfer to the appropriate label by means of a computed go to statement. The weapon type of the firer keys this transfer.

Line 5 labels the XML and DIVAD section of the routine.





Lines 6-9 test the status of the HITSHOT and MISSSHOT attributes of the firer. Two misses or two hits (K-kills) cause the hit and miss counters and FOE attributes of the firer to be reset to 0. A movement to a full defilade position is accomplished and control is returned to event IMPACT.

Lines 10-11 are executed if the hit and miss test above fails. These lines insure that the required ammunition is available prior to firing again on the same target.

Lines 12-14 label the IFV, ITV, and DRAGON section of the routine.

Lines 15-16 count the number of rounds fired from the same position. If this sum is greater than or equal to 2, then hit and miss counters are reset to 0, the FOE attribute of the firer is reset to 0, a movement to defilade is accomplished and control is returned to event IMPACT.

Lines 17-19 label the T72, BMP, and ZSU section of the routine.

Lines 20-21 reset the FOE attribute of the firer to 0, and schedule an immediate TARGET.SELECT. This applies to all weapons of type T72, BMP, and ZSU. It also applies to



Lines 31-33 are similar to lines 27-30 except that they apply to RED TANKs.

Lines 34-36 increment by one the total number of rounds fired at the TANK and return control to event IMPACT.

## JJ. ROUTINE WE.MISS

### Description

Routine WE.MISS is used by event IMPACT when anything other than a catastrophic kill (K-kill) is registered by the firer. Depending on the number of rounds fired and the weapon type of the firer, routine WE.MISS causes a movement to defilade, a target selection, or another engagement of the current target.

### Local Variables

The following are local variables of this routine:

A - An integer variable containing the pointer value of the TANK for which a movement to defilade, target selection, or second engagement is required.

ANSWER - The returned argument from routine AMMO.CHECK.

An ANSWER=1 indicates that the required ammunition is available. An ANSWER = 0 indicates the converse.



weapons of type XML and DIVAD which do not have the ammunition type required to re-engage their current FOE. Control is returned to event IMPACT.

Lines 22-27 calculate the current range to the target, schedule a FIRE event in the appropriate amount of time, and set the CHECK.TIME attribute of the firer to the time for which the fire is scheduled. Control is then returned to event IMPACT.

KK. ROUTINE WE.HIT

#### Description

Routine WE.HIT is used by event IMPACT when a catastrophic kill (K-kill) is inflicted by the firer. Depending on the number of rounds fired previously and the weapon type of the firer, routine WE.HIT causes a movement to defilade (event HIDE) or another target selection. A discussion of specific firing tactics for each weapon system was presented in chapter III.

#### Local Variables

The following is a local variable of this routine:

A - An integer variable containing the pointer value of the TANK for which a movement to defilade or target selection is required.



## Coding and Brief Explanation

The coding for routine WE.HIT is shown below, followed by a brief explanation:

```
1  ROUTINE WE.HIT(A)
2  DEFINE A AS AN INTEGER VARIABLE
3  LET HITSHOT(A) = HITSHOT(A) + 1
4  GO TO XML,XM1,IFV,ITV,DIVAD,DRAGON,T72,BMP,ZSU  PER
WPN.TYPE(A)
5  'XML'      'DIVAD'
6  IF (HITSHOT(A) EQ 2) OR (MISSSHOT(A) EQ 2) OR
7  (HITSHOT(A) EQ 1 AND MISSSHOT(A) EQ 1)
8  'MOVE'
9  LET FOE(A) = 0
10 LET HITSHOT(A) = 0 LET MISSSHOT(A) = 0
11 SCHEDULE A HIDE(A,1) NOW
12 RETURN ELSE GO TO ZSU
13 'IFV'
14 'ITV'
15 'DRAGON'
16 IF HITSHOT(A) + MISSSHOT(A) GE 2
17 GO TO MOVE ELSE GO TO T72
18 'T72'
```





```
19  'BMP'  
20  'ZSU'  
21  SCHEDULE A TARGET.SELECT(A) NOW RETURN  
22  END
```

Lines 1-2 define the routine and local variable.

Line 3 increments the HITSHOT attribute of the firer by one.

Line 4 directs a transfer to the appropriate label by means of a computed go to statement. The weapon type of the firer keys this transfer.

Line 5 labels the XML and DIVAD section of the routine.

Lines 6-10 test the status of the HITSHOT and MISSSHOT attributes of the firer. Two misses, two hits (K-kills), or a miss followed by a hit cause the hit and miss counters to be reset to 0, effect a movement to defilade and return control to event IMPACT.

Lines 11-13 label the IFV, ITV and DRAGON sections of the routine. They also serve as a transfer point if lines 6 and 7 are not true.

Line 14 counts the sum of the number of rounds fired from the current position. If this sum is greater than or equal to 2, the hit and miss counters are reset to 0,



program flow is transferred to line 9, a movement to defilade is effected and control is returned to event IMPACT.

Lines 16-18 label the T72, BMP, and ZSU section of the routine. These lines also serve as a transfer point if line 14 is not true.

Line 19 schedules an immediate TARGET.SELECT for weapons of type T72, BMP, and ZSU. Moreover, if BLUE weapon systems have failed their hit and miss counter tests, a TARGET.SELECT is also scheduled for these weapon systems.



## V. INPUT REQUIREMENTS

### A. SIMSCRIPT INPUT

#### General

All SIMSCRIPT input to STAR is in free field card input; that is, each data value must be separated by a blank space. This is the only formatting requirement for SIMSCRIPT input. A sample card or cards follows the discussion of each set of input values described below.

#### R.NUM.ALIVE, B.NUM.ALIVE, and DELTA.T

R.NUM.ALIVE and B.NUM.ALIVE are integer values equal to the number of RED and BLUE TANKs to be created. DELTA.T is a real variable whose value is the time in seconds between detection scheduling events (event STEP.TIME). These values could appear on a card as:

162 77 15.0

which represent 162 RED TANKs, 77 BLUE TANKs, and a DELTA.T of 15 seconds.

#### PNUM and CNUM

PNUM and CNUM refer to the number of platoon and company sets to be created. These values could appear on a data card as:

63 15

which represent 63 platoons and 15 companies.

#### X.STOP, Y.STOP, R.PCT.ATT, and B.PCT.ATT

X.STOP and Y.STOP are real variables which are the coordinates at which RED TANKs are halted. The battlefield is a 10 kilometer by 10 kilometer square and the values for



these coordinates may range from 0.0 to 10000.0. R.PCT.ATT and B.PCT.ATT are the attrition percentages for RED and BLUE forces, which, if equaled or exceeded, will stop the simulation. Both are real variables ranging from 0.0 to 1.0. These 4 values might appear on a data card as:

2500.0 2000.0 .90 .80

which represent an X.STOP coordinate of 2500.0, a Y.STOP coordinate of 2000.0, a RED attrition point of 90 percent, and a BLUE attrition point of 80 percent.

### DS1 and DS2

Each force has a danger state array: DS1 for BLUE forces and DS2 for RED forces. The rows of each array are keyed to the weapon type of the firer and the range band of the target (less than 1000 meters, between 1000 and 2000 meters, and greater than 2000 meters). Consequently, each firer will have three rows, one for each range band. The columns are keyed to the number of target types available. Each target type has a set of 8 columns assigned to it. A macro look at DS1 would reveal a format similar to the one below where each block (\*) represents 3 rows and 8 columns.

| TARGET |     |     |     |
|--------|-----|-----|-----|
|        | T72 | BMP | ZSU |
| XML    | *   |     |     |
| IFV    |     |     |     |
| ITV    |     |     |     |
| DIVAD  |     |     |     |
| DRAGON |     |     |     |





The total dimension of this array is (5 x 3) by (3 x 8) or 360 values.

A micro look at the XML-T72 block (\*) would show:

|     |    | T72 |    |   |    |    |    |    |
|-----|----|-----|----|---|----|----|----|----|
|     |    | 1   | 1  | 2 | 2  | 99 | 99 | 99 |
| XML | 21 | 1   | 22 | 2 | 99 | 99 | 99 | 99 |
|     | 41 | 1   | 43 | 2 | 99 | 99 | 99 | 99 |

Consider the first row which represents the less than 1000 meter rangeband. The numbers in the columns are to be read in pairs. For example, the first and second numbers in row 1 form the pair (1,1) and mean that the XML's first priority in this rangeband is a T72, and the preferred ammunition for use against the T72 is type 1, APDS. The T72 is also second priority within this rangeband using ammunition type 2, HEAT.

Looking at the second row, the 1000-2000 meter rangeband, reveals a similar ordering and ammunition selection. The T72 is still first and second priority within the rangeband, a constant value of 20 being added to priorities in the second row. Any constant could be added to the basic priority value in a row, but the resulting priority number must be larger than the largest priority number in a prior row associated with that firer. An exception to this rule are the entries with value 99. These values are used as stopping values when routine PRIORITY.AND.ROUND.SELECT accesses a danger state array. When a priority of 99 is



retrieved from the array, this indicates that the target type should not be engaged.

In the third rangeband, the T72 is again first priority with ammunition type 1, APDS, and then drops to third priority with ammunition type 2, HEAT. An examination of the complete set of danger state array rows and columns associated with the XM1 (Table III) provides an explanation of this priority situation.

In row 3 (the greater than 2000 meter rangeband) the BMP assumes second priority using ammunition type 2, HEAT.

Note in row 1 that ammunition type 3 (.50 caliber machingun for the XM1) is used against the BMP and ZSU. Use of ammunition type 3 is restricted to targets in this range band only. This reflects the relatively short effective range of small caliber ammunition.

The remaining rows and columns of DS1 are constructed in a similar manner. DS2 is formed the same way except the RED force firers are used in constructing rows and BLUE force targets are used in constructing columns. DS1 and DS2 are shown in their entirety in tables IV and V.

To input these values, the user may type each row on one or more cards. Each value is an integer separated from the next value one or more spaces.

The first 2 rows of DS1 as prepared for input in the current version of STAR are shown below: In this case each 2 cards represent 1 row of the DS1 array.



TABLE III

XML PORTION - DSL

|     |    |   |    |   |    |    |    |    |    |    |   |    |   |    |    |    |    |    |   |    |   |    |    |    |    |
|-----|----|---|----|---|----|----|----|----|----|----|---|----|---|----|----|----|----|----|---|----|---|----|----|----|----|
| XML | 1  | 1 | 2  | 2 | 99 | 99 | 99 | 99 | 99 | 3  | 2 | 4  | 1 | 5  | 3  | 99 | 99 | 6  | 1 | 7  | 2 | 8  | 3  | 99 | 99 |
|     | 21 | 1 | 22 | 2 | 99 | 99 | 99 | 99 | 99 | 23 | 2 | 24 | 1 | 99 | 99 | 99 | 99 | 25 | 1 | 26 | 2 | 99 | 99 | 99 | 99 |
|     | 41 | 1 | 43 | 2 | 99 | 99 | 99 | 99 | 99 | 42 | 2 | 44 | 1 | 99 | 99 | 99 | 99 | 45 | 1 | 46 | 2 | 99 | 99 | 99 | 99 |



TABLE IV

BLUE DANGER STATE ARRAY - DS1

```

1 1 2 2 2 99 99 99 99 99 99 3 2 4 1 5 3 99 99 99 6 1 7 2 8 3 99 99
21 1 22 2 99 99 99 99 99 99 23 2 24 1 99 99 99 99 25 1 26 2 99 99 99
31 1 33 2 99 99 99 99 99 99 32 2 34 1 99 99 99 99 35 1 36 2 99 99 99
3 1 99 99 99 99 99 99 1 3 2 1 99 99 99 99 4 3 5 1 99 99 99 99
21 1 99 99 99 99 99 99 22 1 23 3 99 99 99 99 24 1 25 3 99 99 99 99
31 1 99 99 99 99 99 99 32 1 99 99 99 99 99 99 33 1 99 99 99 99 99
1 1 99 99 99 99 99 99 2 1 99 99 99 99 99 99 3 1 99 99 99 99 99
21 1 99 99 99 99 99 99 22 1 99 99 99 99 99 99 23 1 99 99 99 99 99
31 1 99 99 99 99 99 99 32 1 99 99 99 99 99 99 33 1 99 99 99 99 99
8 8 99 99 99 99 99 99 2 3 99 99 99 99 99 99 1 3 99 99 99 99 99
99 99 99 99 99 99 99 99 22 3 99 99 99 99 99 99 21 3 99 99 99 99 99
99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99
1 2 99 99 99 99 99 99 2 2 99 99 99 99 99 99 3 2 99 99 99 99 99
99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99
99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99

```





TABLE V

RED DANGER STATE ARRAY - DS2

```

1 1 2 2 99 99 99 99 3 2 5 1 9 3 99 99 4 2 6 1 10 3 99 99 11 1 12 2 99 99 99
7 2 8 3 99 99 99 99
21 1 22 2 99 99 99 99 24 2 26 1 31 3 99 99 23 2 25 1 30 3 99 99 27 2 28 1
99 99 99 99 29 3 99 99 99 99
41 1 44 2 99 99 99 99 43 2 46 1 99 99 99 99 42 2 45 1 99 99 99 99 47 2 48 1 99
99 99 99 99 99 99 99 99 99 99
21 99 99 99 99 99 99 1 3 3 1 99 99 99 99 4 3 5 1 99 99 99 99 6 1 7 3 99 99 99
99
8 3 9 1 99 99 99
21 1 99 99 99 99 99 99 23 1 25 3 99 99 99 22 1 24 3 99 99 99 26 1 27 3 99
99 99 99 28 3 99 99 99 99 99
41 1 99 99 99 99 99 99 43 1 99 99 99 99 99 42 1 99 99 99 99 99 44 1 99 99
99 99 99 99 99 99 99 99
99 99 99 99 99 99 99 2 3 99 99 99 99 99 3 3 99 99 99 99 99 1 3 99 99 99
99 99 99 4 3 99 99 99 99 99
99 99 99 99 99 99 99 23 3 99 99 99 99 99 22 8 99 99 99 99 99 21 3
99 99 99 99 99 99 99 99 99 99
99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99
99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99
99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99

```



```

CARD 1      1  1  2  2 99 99 99 99  3  2  4  1
CARD 2      5  3 99 99  6  1  7  2  8  3 99 99
CARD 3     21  1 22  2 99 99 99 99 23  2 24  1
CARD 4     99 99 99 99 25  1 26  2 99 99 99 99

```

### Attributes

A number of attributes of the temporary entities, TANKs, must be input on data cards. In the discussion that follows, real variables will be denoted by an R in parentheses following the attribute name. Real attributes may be input with or without decimal points. Integer attributes will be denoted by an I-xxxx in parentheses following the attribute name. The xxxx sequence represents the maximum numerical value that the attribute may be assigned. These maximum sizes must be strictly observed since many of the integer attributes are bit packed (see the discussion of the PREAMBLE). Integer attributes may not be input with decimal points.

NAME(I-1023) - The first TANK has the name 1 with subsequent TANKs numbered sequentially and the last BLUE TANK assigned a NAME equal to the value of B.NUM.ALIVE. RED TANKs begin with a NAME equal to B.NUM.ALIVE + 1, and end with a NAME equal to the value of R.NUM.ALIVE.

COLOR(I-1) - A value of 1 indicates a BLUE TANK. A value of 0 denotes a RED TANK.

WPN.TYPE(I-31) - The nine weapon types and their codes are shown below:



- 1 - XM1(105mm main gun)
- 2 - XM1(120mm main gun)
- 3 - IFV
- 4 - ITV
- 5 - DIVAD
- 6 - DRAGON
- 7 - T72
- 8 - BMP
- 9 - ZSU

VEH.TYPE(I-31) - The 12 weapon types and their codes are shown below:

- 1 - XM1(105mm main gun)
- 2 - XM1(120mm main gun, 40 round configuration)
- 3 - XM1(120mm main gun, 43 round configuration)
- 4 - XM1(120mm main gun, 49 round configuration)
- 5 - XM1(120mm main gun, 52 round configuration)
- 6 - IFV
- 7 - ITV
- 8 - DIVAD
- 9 - DRAGON
- 10 - T72
- 11 - BMP
- 12 - ZSU

AP.TOW(I-63) - Ammunition type 1. This represents the initial amount on board. Table I provides a guide to the specific type of ammunition that this and the next three



ammunition types represent with respect to a specific weapon system. If an ammunition type is not carried, a 0 should be entered.

HE.DRAG(I-63) - Ammunition type 2.

AW1.OR.MSL3(I-63) - Ammunition type 3.

AW2.OR.ADM(I-63) - Ammunition type 4.

SEC(I-2047) - The section number assignment. Since this organizational attribute has no effect on execution of STAR, any desired numbering scheme may be used.

PLT(I-2047) - The platoon number assignment. It is important for fire control purposes that TANKs be grouped sequentially in platoons and that TANKs in headquarters elements are assigned to the same platoon. The TANKs in a battalion headquarters, for example, are considered a platoon for fire control purposes and should all have the same platoon number assigned to them.

CO(I-1023) - The company number assignment. The comment above with respect to headquarters elements also applies in making company number assignments.

BN(I-127) - The battalion number assignment. Any numbering scheme may be used.

RGT(I-255) - The regiment number assignment. Any numbering scheme may be used. BLUE forces should have a 0 input.

BDE(I-7) - The brigade number assignment. Any numbering scheme may be used. RED forces should have a 0 input.

DIV(I-7) - The division number assignment. Any numbering scheme may be used.





X.CURRENT(R) - The TANK's initial X coordinate on the battlefield.

Y.CURRENT(R) - The TANK's initial Y coordinate on the battlefield.

SPD(R) - The TANK's initial speed in meters per second.

DIR.OF.MVMT(R) - The TANK's initial direction of movement in mils. An angle measured clockwise from East is negative. An angle measured counterclockwise from East is positive. Angles are entered in mils and converted to radians for use in the program.

PRI.DIR(R) - The primary direction of search measured in the same manner as DIR.OF.MVMT.

M1, M2, M3, M4(all I-65535) - The muzzle velocities in meters per second associated with each of the four ammunition types carried by the TANK. If an ammunition is not carried by a TANK, the associated velocity should be input as 0.

COCDR(I-9999999) - The NAME of the TANK's company commander. If the TANK is to be the company commander, the TANK's own NAME SHOULD be entered here and also for the PLTLDR and SECLDR attributes described below.

PLTLDR(I-9999999) - The NAME of a TANK's platoon leader. If the TANK is to be the platoon leader, the TANK's own NAME should be entered here and also for the SECLDR attribute described below.



SECLDR(I-9999999) - The NAME of a TANK's section leader.

If the TANK is to be the section leader, the TANK's own name should be entered here.

OP.RNG(I-4095) - The TANK's maximum opening range in meters.

A complete example of attribute input is shown in table VI. A brief example showing the relationship of the NAME, organization and leader attributes is shown below:

| NAME | SEC | PLT | CO | COCDR | PLTLDR | SECLDR |
|------|-----|-----|----|-------|--------|--------|
| 1    | 1   | 1   | 1  | 1     | 1      | 1      |
| 2    | 1   | 1   | 1  | 1     | 1      | 1      |
| 3    | 2   | 2   | 1  | 1     | 3      | 3      |
| 4    | 2   | 2   | 1  | 1     | 3      | 3      |
| 5    | 2   | 2   | 1  | 1     | 3      | 3      |
| 6    | 3   | 2   | 1  | 1     | 3      | 6      |
| 7    | 3   | 2   | 1  | 1     | 3      | 6      |
| 8    | 4   | 3   | 1  | 1     | 8      | 8      |
| 9    | 4   | 3   | 1  | 1     | 8      | 8      |
| 10   | 4   | 3   | 1  | 1     | 8      | 8      |
| 11   | 5   | 3   | 1  | 1     | 8      | 11     |
| 12   | 5   | 3   | 1  | 1     | 8      | 11     |
| 13   | 6   | 3   | 2  | 13    | 13     | 13     |
| 14   | 6   | 4   | 2  | 13    | 13     | 13     |
| 15   | 7   | 5   | 2  | 13    | 13     | 15     |
| 16   | 7   | 5   | 2  | 13    | 15     | 15     |
| 17   | 7   | 5   | 2  | 13    | 15     | 15     |
| 18   | 8   | 5   | 2  | 13    | 15     | 18     |



|    |    |   |   |    |    |    |
|----|----|---|---|----|----|----|
| 19 | 8  | 5 | 2 | 13 | 15 | 18 |
| 20 | 9  | 6 | 2 | 13 | 20 | 20 |
| 21 | 9  | 6 | 2 | 13 | 20 | 20 |
| 22 | 9  | 6 | 2 | 13 | 20 | 20 |
| 23 | 10 | 6 | 2 | 13 | 20 | 23 |
| 24 | 10 | 6 | 2 | 13 | 20 | 23 |

## B. FORTRAN INPUT

FORTRAN input will not be discussed in this thesis since it is assumed that most readers are familiar with entering FORTRAN data. FORTRAN input required by the terrain model used in the current version of STAR may be obtained from Professor James K. Hartman, Naval Postgraduate School.



TABLE VI

## SAMPLE ATTRIBUTE INPUT VALUES

INPUT SHOWN BELOW IS IN THE FOLLOWING ATTRIBUTE ORDER WITH 4 DATA CARDS PER TANK

|            |           |           |          |           |         |           |
|------------|-----------|-----------|----------|-----------|---------|-----------|
| NAME       | COLOR     | WPN.TYPE  | VEH.TYPE | AP.TOW    | HE.DRAG | AW1.OR.MS |
| AW2.OR.ADM | SEC       | PLT       | CC       | BN        | RGT     | BDE       |
| LIV        | X.CURRENT | Y.CURRENT | SPD      | DIR.OF.MV | PRI.DIR | M1        |
| M2         | M3        | M4        | COCOR    | PLTLDR    | SECLDR  | OP.RNG    |

NOTE THAT THE AW1.OR.MSL3 AND DIR.OF.MVMT ATTRIBUTE NAMES HAVE BEEN TRUNCATED FOR COLUMN SPACING AND HEADING PURPOSES. THE FOLLOWING SAMPLE DATA IS FOR A SIMULATION OF 31 BLUE TANKS VERSUS 53 RED TANKS:

|      |      |      |      |     |    |      |
|------|------|------|------|-----|----|------|
| 1    | 1    | 2    | 2    | 24  | 16 | 100  |
| 0    | 1    | 1    | 1    | 1   | 0  | 1    |
| 1200 | 4540 | 5500 | 5500 | 500 | 0  | 1400 |
| 1    | 2000 | 0    | 0    | 24  | 16 | 2600 |
| 2    | 1    | 2    | 1    | 24  | 0  | 100  |
| 0    | 1    | 1    | 1    | 210 | 0  | 1    |
| 1200 | 4970 | 5360 | 5360 | 210 | 0  | 1400 |
| 1    | 2000 | 0    | 0    | 1   | 0  | 2600 |
| 3    | 1    | 4    | 1    | 0   | 0  | 0    |
| 0    | 1    | 1    | 1    | 1   | 0  | 1    |
| 1    | 4910 | 5480 | 5480 | 500 | 0  | 0    |
| 0    | 1    | 0    | 0    | 1   | 0  | 0    |
| 4    | 1    | 2    | 1    | 24  | 16 | 100  |
| 0    | 1    | 1    | 1    | 711 | 0  | 1    |
| 1200 | 5300 | 5690 | 5690 | 711 | 4  | 1400 |
| 1    | 2000 | 0    | 0    | 24  | 0  | 2600 |
| 5    | 1    | 2    | 1    | 24  | 16 | 100  |
| 0    | 1    | 2    | 1    | 408 | 0  | 1    |
| 1200 | 5400 | 5420 | 5420 | 408 | 0  | 1400 |
| 1    | 2000 | 0    | 0    | 24  | 16 | 2600 |
| 6    | 1    | 2    | 1    | 24  | 0  | 100  |
| 0    | 1    | 2    | 1    | 1   | 0  | 1    |
| 1200 | 5365 | 5500 | 5500 | 622 | 4  | 1400 |
| 1    | 2000 | 0    | 0    | 24  | 0  | 2600 |
| 7    | 1    | 2    | 1    | 24  | 16 | 100  |
| 0    | 1    | 2    | 1    | 942 | 0  | 1    |
| 1200 | 5300 | 5820 | 5820 | 942 | 7  | 1400 |
| 1    | 2000 | 0    | 0    | 4   | 0  | 2600 |





TABLE VI (CONTINUED)

[illegible]



TABLE VI (CONTINUED)

[illegible]



TABLE VI (CONTINUED)

[illegible]



TABLE VI (CONTINUED)

|      |      |      |     |       |     |      |
|------|------|------|-----|-------|-----|------|
| 41   | 0    | 7    | 9   | 18    | 22  | 100  |
| 1300 | 6780 | 8120 | 345 | -2400 | 10  | 1600 |
| 42   | 2000 | 0    | 345 | 18    | 392 | 2600 |
| 1300 | 0    | 7    | 5   | -2400 | 10  | 100  |
| 43   | 6830 | 8070 | 345 | 3     | 392 | 1600 |
| 1300 | 2000 | 0    | 345 | 18    | 10  | 2600 |
| 44   | 0    | 11   | 345 | -2400 | 32  | 100  |
| 1300 | 6500 | 8000 | 345 | 43    | 10  | 1600 |
| 45   | 2000 | 0    | 345 | 18    | 432 | 2600 |
| 1300 | 6520 | 7950 | 345 | -2400 | 10  | 100  |
| 46   | 0    | 11   | 345 | 43    | 432 | 1600 |
| 1300 | 6970 | 7920 | 345 | -2400 | 10  | 2600 |
| 47   | 2000 | 7    | 345 | 18    | 432 | 100  |
| 1300 | 7000 | 11   | 345 | -2400 | 10  | 1600 |
| 48   | 0    | 12   | 345 | 43    | 432 | 2600 |
| 1300 | 6580 | 8580 | 345 | -2400 | 10  | 100  |
| 49   | 1600 | 0    | 345 | 47    | 470 | 40   |
| 1300 | 0    | 8    | 345 | -2400 | 10  | 200  |
| 50   | 6660 | 1200 | 345 | 47    | 470 | 40   |
| 1300 | 1600 | 8500 | 345 | -2400 | 10  | 3000 |
| 51   | 0    | 12   | 345 | 47    | 470 | 40   |
| 1300 | 6800 | 8350 | 345 | -2400 | 10  | 200  |
| 52   | 1600 | 8    | 345 | 47    | 470 | 40   |
| 1300 | 6880 | 1200 | 345 | -2400 | 10  | 3000 |
| 53   | 0    | 13   | 345 | 47    | 470 | 40   |
| 1300 | 7450 | 7850 | 51  | -2400 | 10  | 200  |
| 54   | 2000 | 0    | 51  | 51    | 422 | 100  |
| 1300 | 0    | 13   | 51  | -2400 | 10  | 1600 |
| 55   | 0    | 13   | 51  | 51    | 51  | 2600 |





TABLE VI (CONTINUED)

|      |      |    |       |    |      |
|------|------|----|-------|----|------|
| 52   | 7    | 5  | 18    | 22 | 100  |
| 0    | 14   | 4  | 1     | 0  | 0    |
| 6090 | 7820 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 52    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 14   | 4  | 1     | 0  | 0    |
| 7075 | 7775 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 52    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 14   | 4  | 1     | 0  | 0    |
| 7140 | 7700 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 52    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 14   | 4  | 1     | 0  | 0    |
| 7170 | 7675 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 52    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 14   | 4  | 1     | 0  | 0    |
| 7220 | 7630 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 56    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 15   | 4  | 1     | 0  | 0    |
| 7290 | 7550 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 56    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 15   | 4  | 1     | 0  | 0    |
| 7325 | 7480 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 56    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 15   | 4  | 1     | 0  | 0    |
| 7420 | 7400 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 56    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 16   | 4  | 1     | 0  | 0    |
| 7500 | 7340 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 60    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 16   | 4  | 1     | 0  | 0    |
| 7540 | 7305 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 60    | 0  | 2600 |
| 0    | 7    | 9  | 18    | 22 | 100  |
| 0    | 16   | 4  | 1     | 0  | 0    |
| 7580 | 7275 | 5  | -2400 | 52 | 1600 |
| 2000 | 0    | 51 | 60    | 0  | 2600 |



TABLE VI (CONTINUED)

|      |      |    |    |       |    |      |
|------|------|----|----|-------|----|------|
| 63   | 0    | 7  | 9  | 18    | 22 | 100  |
| 1300 | 760  | 16 | 4  | -2400 | 10 | 1600 |
| 64   | 2000 | 0  | 51 | 60    | 60 | 2600 |
| 1    | 0    | 17 | 10 | 81    | 10 | 40   |
| 1    | 7360 | 0  | 51 | -2400 | 64 | 200  |
| 65   | 1600 | 8  | 10 | 64    | 0  | 3000 |
| 0    | 0    | 17 | 4  | 81    | 10 | 40   |
| 1    | 7430 | 0  | 51 | -2400 | 64 | 200  |
| 66   | 1600 | 0  | 10 | 64    | 0  | 3000 |
| 0    | 0    | 17 | 4  | 81    | 10 | 40   |
| 1    | 7540 | 0  | 51 | -2400 | 64 | 200  |
| 67   | 1600 | 8  | 10 | 64    | 0  | 3000 |
| 0    | 0    | 17 | 4  | 81    | 10 | 40   |
| 1    | 7600 | 0  | 51 | -2400 | 64 | 200  |
| 68   | 1600 | 7  | 51 | 64    | 0  | 3000 |
| 0    | 0    | 17 | 4  | 81    | 10 | 40   |
| 1    | 8220 | 0  | 51 | -2400 | 64 | 200  |
| 69   | 2000 | 18 | 5  | 68    | 22 | 1600 |
| 1300 | 0    | 0  | 68 | 18    | 10 | 2600 |
| 0    | 0    | 7  | 5  | 18    | 68 | 100  |
| 1    | 7730 | 19 | 5  | -2400 | 22 | 1600 |
| 70   | 2000 | 0  | 68 | 65    | 10 | 2600 |
| 0    | 0    | 19 | 5  | 18    | 68 | 100  |
| 1300 | 7800 | 0  | 68 | -2400 | 22 | 1600 |
| 71   | 2000 | 7  | 5  | 65    | 10 | 2600 |
| 0    | 0    | 19 | 5  | 18    | 68 | 100  |
| 1    | 7890 | 0  | 68 | -2400 | 22 | 1600 |
| 72   | 2000 | 19 | 5  | 65    | 10 | 2600 |
| 0    | 0    | 7  | 5  | 18    | 68 | 100  |
| 1300 | 7900 | 0  | 68 | -2400 | 22 | 1600 |
| 73   | 2000 | 19 | 5  | 65    | 10 | 2600 |
| 0    | 0    | 7  | 5  | 18    | 68 | 100  |
| 1    | 7950 | 0  | 68 | -2400 | 22 | 1600 |
| 74   | 2000 | 7  | 5  | 65    | 10 | 2600 |
| 0    | 0    | 19 | 5  | 18    | 68 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 75   | 2000 | 20 | 5  | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 76   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 77   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 78   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 79   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 80   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 81   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 82   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 83   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 84   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 85   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 86   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 87   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 88   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 89   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 90   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 91   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 92   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 93   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 94   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 95   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 96   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 97   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 98   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 99   | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1    | 7960 | 0  | 68 | -2400 | 22 | 1600 |
| 100  | 2000 | 0  | 68 | 73    | 10 | 2600 |
| 0    | 0    | 0  | 68 | 1     | 73 | 100  |
| 1300 | 7960 | 0  | 68 | -2400 | 22 | 1600 |



TABLE VI (CONTINUED)

|      |      |      |   |       |    |      |
|------|------|------|---|-------|----|------|
| 74   | 0    | 7    | 5 | 18    | 22 | 100  |
| 1300 | 8020 | 6820 | 5 | -2400 | 10 | 1600 |
| 75   | 2000 | 0    | 5 | 18    | 73 | 2600 |
| 1300 | 0    | 7    | 5 | 18    | 22 | 100  |
| 1300 | 8100 | 6770 | 5 | -2400 | 10 | 1600 |
| 76   | 2000 | 20   | 6 | 18    | 73 | 2600 |
| 1300 | 0    | 7    | 6 | 18    | 22 | 100  |
| 1300 | 8150 | 6700 | 5 | -2400 | 10 | 1600 |
| 77   | 2000 | 0    | 6 | 18    | 73 | 2600 |
| 1300 | 0    | 7    | 5 | 18    | 22 | 100  |
| 1300 | 8200 | 6600 | 5 | -2400 | 10 | 1600 |
| 78   | 2000 | 21   | 6 | 18    | 77 | 2600 |
| 1300 | 0    | 7    | 5 | 18    | 22 | 100  |
| 1300 | 8280 | 6550 | 5 | -2400 | 10 | 1600 |
| 79   | 2000 | 21   | 6 | 18    | 77 | 2600 |
| 1300 | 0    | 7    | 5 | 18    | 22 | 100  |
| 1300 | 8350 | 6480 | 5 | -2400 | 10 | 1600 |
| 80   | 2000 | 21   | 6 | 18    | 77 | 2600 |
| 1300 | 0    | 7    | 5 | 18    | 22 | 100  |
| 1300 | 8430 | 6380 | 5 | -2400 | 10 | 1600 |
| 81   | 2000 | 22   | 6 | 18    | 77 | 2600 |
| 1300 | 0    | 8    | 5 | 18    | 77 | 2600 |
| 82   | 1600 | 7000 | 5 | -2400 | 10 | 200  |
| 1300 | 0    | 0    | 6 | 18    | 81 | 300  |
| 83   | 8150 | 22   | 6 | 18    | 10 | 40   |
| 1300 | 1600 | 8    | 5 | 18    | 10 | 0    |
| 83   | 0    | 6940 | 6 | -2400 | 10 | 200  |
| 1300 | 0    | 22   | 5 | 18    | 81 | 300  |
| 83   | 8300 | 22   | 5 | 18    | 10 | 40   |
| 1300 | 1600 | 6800 | 5 | -2400 | 10 | 200  |
| 84   | 0    | 8    | 6 | 18    | 81 | 300  |
| 1300 | 0    | 22   | 5 | 18    | 10 | 40   |
| 1300 | 8350 | 6700 | 5 | -2400 | 10 | 200  |
| 85   | 1600 | 0    | 6 | 18    | 81 | 300  |



## VI. SIMULATED BATTLE

The following is a typical battle simulated using the STAR model. This particular battle has a BLUE company team defending against an attacking RED tank battalion reinforced with a motorized rifle company. A VERSATEC plot of the parametric terrain used for this battle is shown in figure 13.

### BLUE Task Organization

#### Team C

Tank Company (-)

2 Mech Inf Platoons

2 Anti-Tank Sections

#### BLUE Weapon Systems Simulated:

12 XM1 (5 per platoon, 2 in Company Headquarters)

8 IFV (4 per Mechanized Infantry Platoon)

4 ITV (2 per Anti-Tank Section)

1 M113 (Forward Observer Vehicle)

#### Initial Ammunition Load, BLUE Weapon Systems:

XM1: 24 rounds APDS

16 rounds HEAT

1000 rounds caliber 50 (stored as 100 bursts of  
10 rounds each)





IFV: 6 rounds TOW  
1000 rounds Bushmaster (stored as 100 bursts of  
10 rounds each  
ITV: 8 rounds TOW  
DRAGON: 6 rounds per DRAGON team  
M113: F0 carrier, non-firing vehicle

BLUE positions on the battlefield are shown in figure 5.

### RED Task Organization

#### RED Tank Bn (+)

| <u>Team 1</u> | <u>Team 2</u> | <u>Team 3</u> |
|---------------|---------------|---------------|
| 1st Tank Co   | 2nd Tank Co   | 3rd Tank Co   |
| 1 Plt BMPs    | 1 Plt BMPs    | 1 Plt BMPs    |

#### Red Weapon Systems Simulated:

40 T72 (13 per company team, 1 per Battalion Headquarters)  
13 BMP (4 per platoon, 1 per BMP company headquarters)

#### Initial Ammunition Load, RED Weapon Systems:

T72: 22 rounds APDS  
18 rounds HEAT  
1000 rounds 12.7mm MG (stored as 100 bursts of 10  
rounds each)  
BMP: 8 rounds SAGGER  
40 rounds 73mm



Spacing of RED elements in the attack is shown in figures 3 and 4. Direction of RED attack on the battlefield is shown in figure 5. Symbols used to depict weapon systems on the battlefield are shown in figure 2.

The following pages trace the progress of the simulated battle over time. Each "time slice" of the battle is represented by a table which catalogs each round fired in the simulation, followed by a narrative description of the battle. The reader's attention is drawn to particular portions of the output which will help in understanding the progress of the battle and the workings of the model. Each narrative description is followed by a map of the battle area on which are plotted those weapon systems which were destroyed during the time period being examined. Each weapon on the map has a number adjacent to it which corresponds to the number of the round which destroyed the target.

To illustrate how one might trace the battle using the rounds fired table and the battle map, figure 1 is provided:



RND: indicates round fired (cumulative total)

FIR: name (number) of firing weapon system

TYPE: indicates type of weapon that fired

AM: indicates type of ammunition fired (see Figure )

TGT: name (number) of target weapon system

TYPE: indicates type of weapon fired at

TIME.V: simulated time of battle

STAT: result of round fired

blank-indicates miss

DEAD-indicates target destroyed

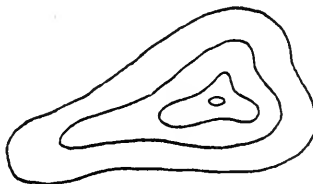
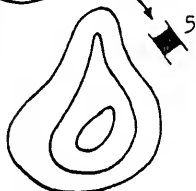
HIDE-indicates target in full defilade when  
round impacted

RANGE: range to target

X-FIR Y-FIR: X,Y coordinate of firer

X-TGT Y-TGT: X,Y coordinate of target

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 1   | 7   | XM1  | 1  | 56  | T72  | 24.6   |      | 2496  | 5300  | 5820  | 7238  | 7393  |
| 2   | 58  | T72  | 1  | 7   | XM1  | 31.7   |      | 2461  | 7213  | 7368  | 5300  | 5820  |
| 3   | 52  | T72  | 2  | 28  | IFV  | 32.9   |      | 2429  | 5974  | 7704  | 4760  | 5600  |
| 4   | 7   | XM1  | 1  | 58  | T72  | 32.9   |      | 2455  | 5300  | 5820  | 7209  | 7364  |
| 5   | 22  | ITV  | 1  | 52  | T72  | 35.0   | DEAD | 2799  | 4920  | 5100  | 5966  | 7696  |
| 6   | 27  | IFV  | 1  | 56  | T72  | 38.1   | DEAD | 2455  | 4640  | 5630  | 5935  | 7680  |
| 7   | 66  | BMP  | 1  | 8   | XM1  | 43.7   | HIDE | 2445  | 7215  | 7245  | 5200  | 5860  |



Note that the destroyed vehicle has the number 5 adjacent to it, which corresponds to RND 5 in the rounds fired table. This row of the table indicates that the T72 number 52 was destroyed by ITV number 22 firing ammunition type 1 (TOW) at a range of 2799 meters at 35.0 seconds into the simulation. The X and Y coordinates of the firer and target at the time the round impacted are also indicated.

Figure 1










-  - XM1
-  - T72
-  - IFV
-  - BMP
-  - ITV
-  - DRAGON Team
-  - FO Vehicle

Figure 2 Symbols Used





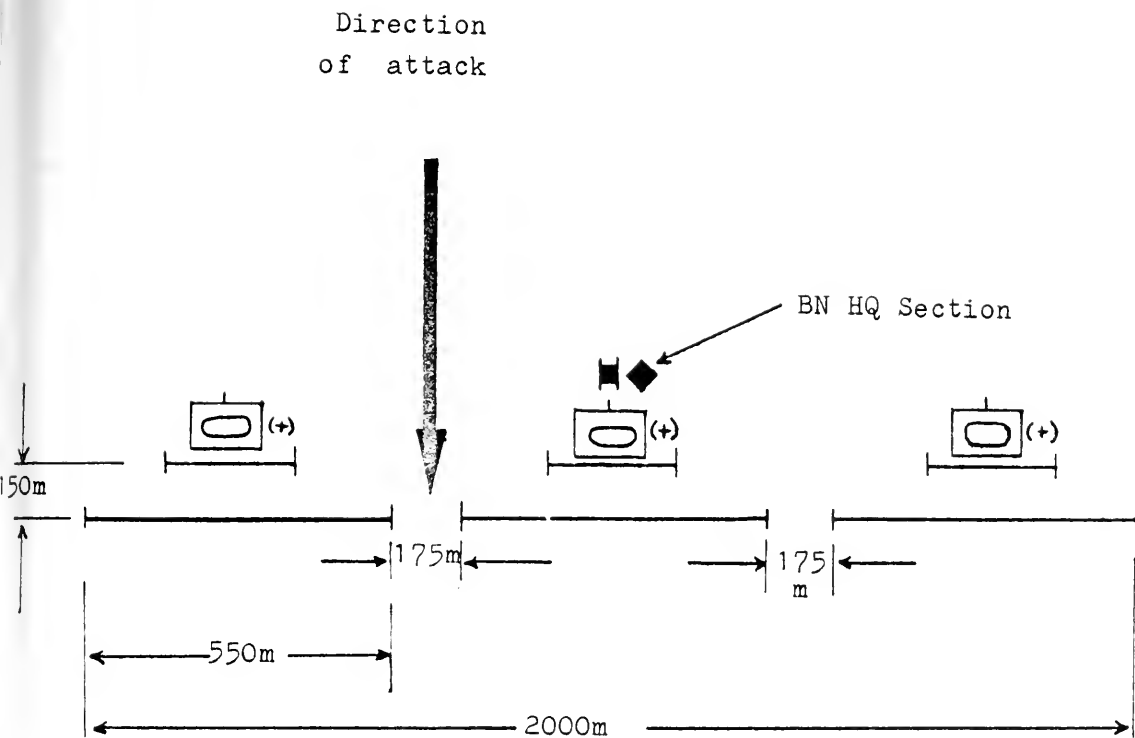


Figure 3 RED Battalion Attack Formation



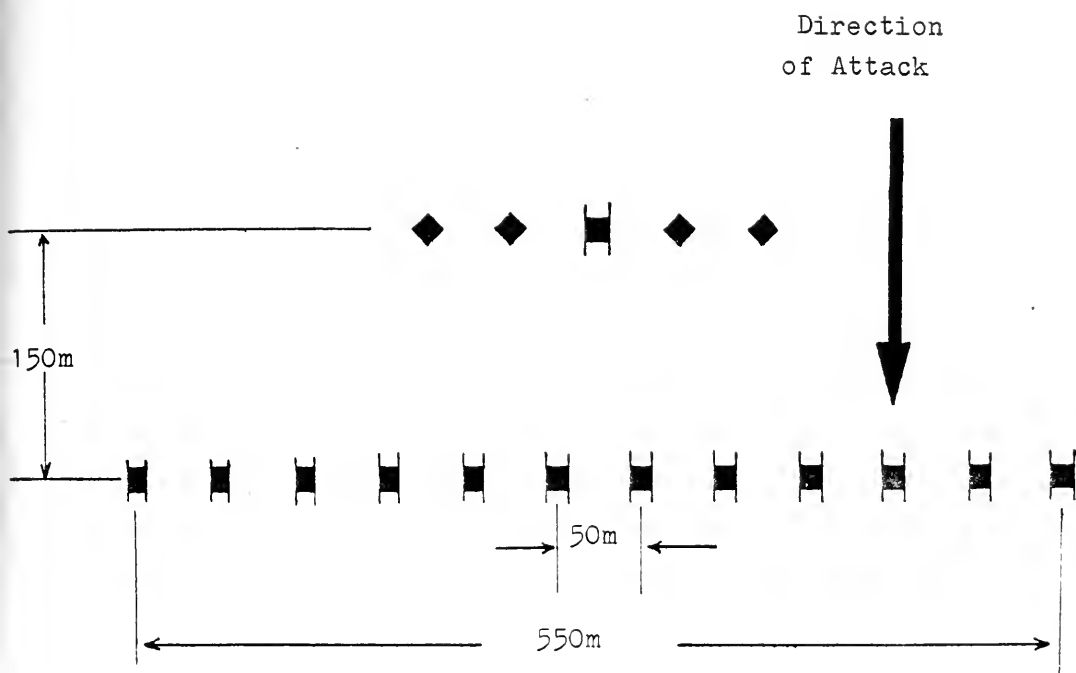


Figure 4 RED Company Formation



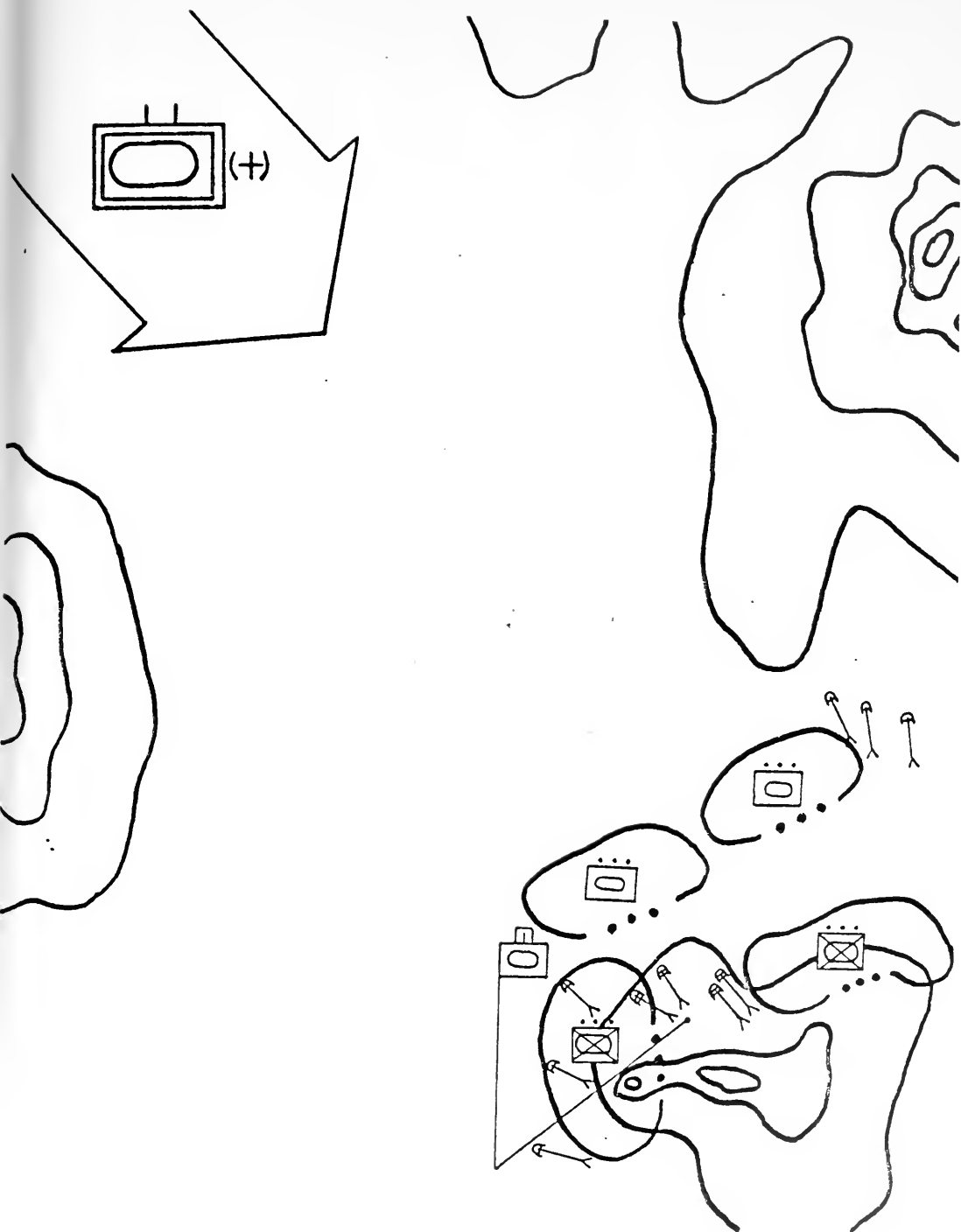


Figure 5 Initial Positions



# Simulated Time 0 thru 104.9 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 1   | 7   | XM1  | 1  | 58  | T72  | 24.6   |      | 2496  | 5300  | 5820  | 7238  | 7393  |
| 2   | 58  | T72  | 1  | 7   | XM1  | 31.7   |      | 2461  | 7213  | 7368  | 5300  | 5820  |
| 3   | 52  | T72  | 2  | 28  | IFV  | 32.9   |      | 2429  | 5974  | 7704  | 4760  | 5600  |
| 4   | 7   | XM1  | 1  | 58  | T72  | 32.9   |      | 2455  | 5300  | 5820  | 7209  | 7364  |
| 5   | 22  | ITV  | 1  | 52  | T72  | 35.0   | DEAD | 2799  | 4920  | 5100  | 5966  | 7696  |
| 6   | 27  | IFV  | 1  | 52  | T72  | 38.1   | DEAD | 2455  | 4640  | 5630  | 5966  | 7696  |
| 7   | 10  | XM1  | 1  | 69  | T72  | 43.7   |      | 2515  | 5710  | 5270  | 7575  | 6955  |
| 8   | 57  | T72  | 1  | 4   | XM1  | 44.3   |      | 2503  | 7133  | 7393  | 5300  | 5690  |
| 9   | 4   | XM1  | 1  | 57  | T72  | 47.7   |      | 2485  | 5300  | 5690  | 7121  | 7381  |
| 10  | 10  | XM1  | 1  | 69  | T72  | 50.0   |      | 2483  | 5710  | 5270  | 7553  | 6933  |
| 11  | 73  | T72  | 1  | 10  | XM1  | 51.0   | HIDE | 2530  | 7782  | 6722  | 5710  | 5270  |
| 12  | 65  | BMP  | 1  | 9   | XM1  | 53.3   | DEAD | 2869  | 7292  | 7562  | 5580  | 5260  |
| 13  | 6   | XM1  | 1  | 58  | T72  | 54.9   |      | 2511  | 5365  | 5500  | 7131  | 7286  |
| 14  | 57  | T72  | 1  | 4   | XM1  | 57.8   |      | 2435  | 7086  | 7346  | 5300  | 5690  |
| 15  | 4   | XM1  | 1  | 57  | T72  | 58.0   |      | 2434  | 5300  | 5690  | 7085  | 7345  |
| 16  | 64  | BMP  | 1  | 12  | XM1  | 59.0   | DEAD | 2931  | 7203  | 7603  | 5800  | 5030  |
| 17  | 11  | XM1  | 1  | 72  | T72  | 60.3   |      | 2515  | 5769  | 5120  | 7687  | 6737  |
| 18  | 6   | XM1  | 1  | 58  | T72  | 62.5   |      | 2474  | 5365  | 5500  | 7104  | 7259  |
| 19  | 28  | IFV  | 1  | 58  | T72  | 63.8   | DEAD | 2865  | 4760  | 5600  | 7099  | 7254  |
| 20  | 74  | T72  | 1  | 11  | XM1  | 66.8   |      | 2498  | 7784  | 6584  | 5760  | 5120  |
| 21  | 11  | XM1  | 1  | 72  | T72  | 67.0   |      | 2482  | 5760  | 5120  | 7663  | 6713  |
| 22  | 8   | XM1  | 1  | 59  | T72  | 72.6   | DEAD | 2346  | 5200  | 5860  | 7163  | 7143  |
| 23  | 7   | XM1  | 1  | 69  | T72  | 72.6   |      | 2407  | 5300  | 5820  | 7473  | 6853  |
| 24  | 5   | XM1  | 1  | 55  | T72  | 73.8   |      | 2501  | 5400  | 5420  | 6909  | 7414  |
| 25  | 72  | T72  | 1  | 10  | XM1  | 74.8   |      | 2390  | 7636  | 6686  | 5710  | 5270  |
| 26  | 70  | T72  | 1  | 7   | XM1  | 78.1   |      | 2428  | 7524  | 6794  | 5300  | 5820  |
| 27  | 69  | T72  | 1  | 7   | XM1  | 78.7   | DEAD | 2378  | 7452  | 6832  | 5300  | 5820  |
| 28  | 13  | XM1  | 1  | 62  | T72  | 79.9   |      | 2479  | 5850  | 4980  | 7298  | 6993  |
| 29  | 5   | XM1  | 1  | 55  | T72  | 81.6   |      | 2462  | 5400  | 5420  | 6882  | 7387  |
| 30  | 57  | T72  | 1  | 6   | XM1  | 86.7   | DEAD | 2379  | 6984  | 7244  | 5365  | 5500  |
| 31  | 64  | BMP  | 1  | 13  | XM1  | 87.3   | DEAD | 2858  | 7134  | 7534  | 5850  | 4980  |
| 32  | 8   | XM1  | 2  | 66  | BMP  | 87.6   |      | 2466  | 5200  | 5860  | 7230  | 7260  |
| 33  | 10  | XM1  | 1  | 69  | T72  | 87.9   |      | 2293  | 5710  | 5270  | 7419  | 6799  |
| 34  | 13  | XM1  | 1  | 62  | T72  | 88.9   | DEAD | 2435  | 5850  | 4980  | 7266  | 6961  |
| 35  | 75  | T72  | 1  | 10  | XM1  | 88.9   |      | 2390  | 7786  | 6456  | 5710  | 5270  |
| 36  | 27  | IFV  | 1  | 46  | T72  | 90.6   | DEAD | 2795  | 4640  | 5630  | 6680  | 7540  |
| 37  | 69  | T72  | 1  | 10  | XM1  | 92.2   |      | 2272  | 7404  | 6784  | 5710  | 5270  |
| 38  | 79  | T72  | 1  | 10  | XM1  | 92.6   |      | 2475  | 8022  | 6152  | 5710  | 5270  |
| 39  | 10  | XM1  | 1  | 69  | T72  | 93.9   |      | 2263  | 5710  | 5270  | 7398  | 6778  |
| 40  | 8   | XM1  | 2  | 66  | BMP  | 94.1   |      | 2445  | 5200  | 5860  | 7215  | 7245  |
| 41  | 77  | T72  | 1  | 10  | XM1  | 94.2   | HIDE | 2383  | 7872  | 6272  | 5710  | 5270  |
| 42  | 28  | IFV  | 1  | 60  | T72  | 97.5   | DEAD | 2772  | 4760  | 5600  | 7155  | 6995  |
| 43  | 4   | XM1  | 1  | 71  | T72  | 98.2   | DEAD | 2441  | 5300  | 5690  | 7543  | 6653  |
| 44  | 65  | BMP  | 1  | 10  | XM1  | 100.3  | HIDE | 2550  | 7123  | 7393  | 5710  | 5270  |
| 45  | 66  | BMP  | 1  | 8   | XM1  | 104.1  | HIDE | 2445  | 7215  | 7245  | 5200  | 5860  |
| 46  | 11  | XM1  | 1  | 72  | T72  | 104.9  |      | 2293  | 5760  | 5120  | 7529  | 6579  |

BLUE elements remaining at 104.9 seconds

| Wpn Type | Number<br>at Start | Number<br>remaining | Average Rnds per Wpn<br>Remaining   |
|----------|--------------------|---------------------|-------------------------------------|
| XM1      | 12                 | 7                   | 22 APDS, 15.71 HEAT,<br>1000 cal 50 |
| IFV      | 8                  | 8                   | 5.5 TOW, 1000 Bushmaster            |
| ITV      | 4                  | 4                   | 7.75 TOW                            |
| DRAGON   | 6                  | 6                   | 6 DRAGON                            |





RED elements remaining at 104.9 seconds

| <u>Wpn Type</u> | <u>Number<br/>at Start</u> | <u>Number<br/>remaining</u> | <u>Average Rnds per Wpn<br/>Remaining</u> |
|-----------------|----------------------------|-----------------------------|---|
| T72             | 40                         | 33                          | 21.64 APDS, 18 HEAT,<br>1000 12.7mm       |
| BMP             | 13                         | 13                          | 7.61 SAGGER, 40 73mm                      |

During the initial changes of the battle, the priority target for all weapon systems is the opposing tank, thus during this portion of the simulation those weapon systems destroyed are all tanks. Each of the BLUE tank platoons in the simulation are reduced significantly during these initial engagements (one platoon is reduced to two tanks, the second platoon is reduced to three tanks). Likewise, the red tanks are the priority target for all BLUE weapon systems.

Note that at rounds 5 and 6 T72 number 52 is impacted by two TOW rounds within 3 seconds of each other. Note also at rounds 11, 41, 44, and 45 XMLs are impacted while in full defilade indicated by the word HIDE in the STAT column.



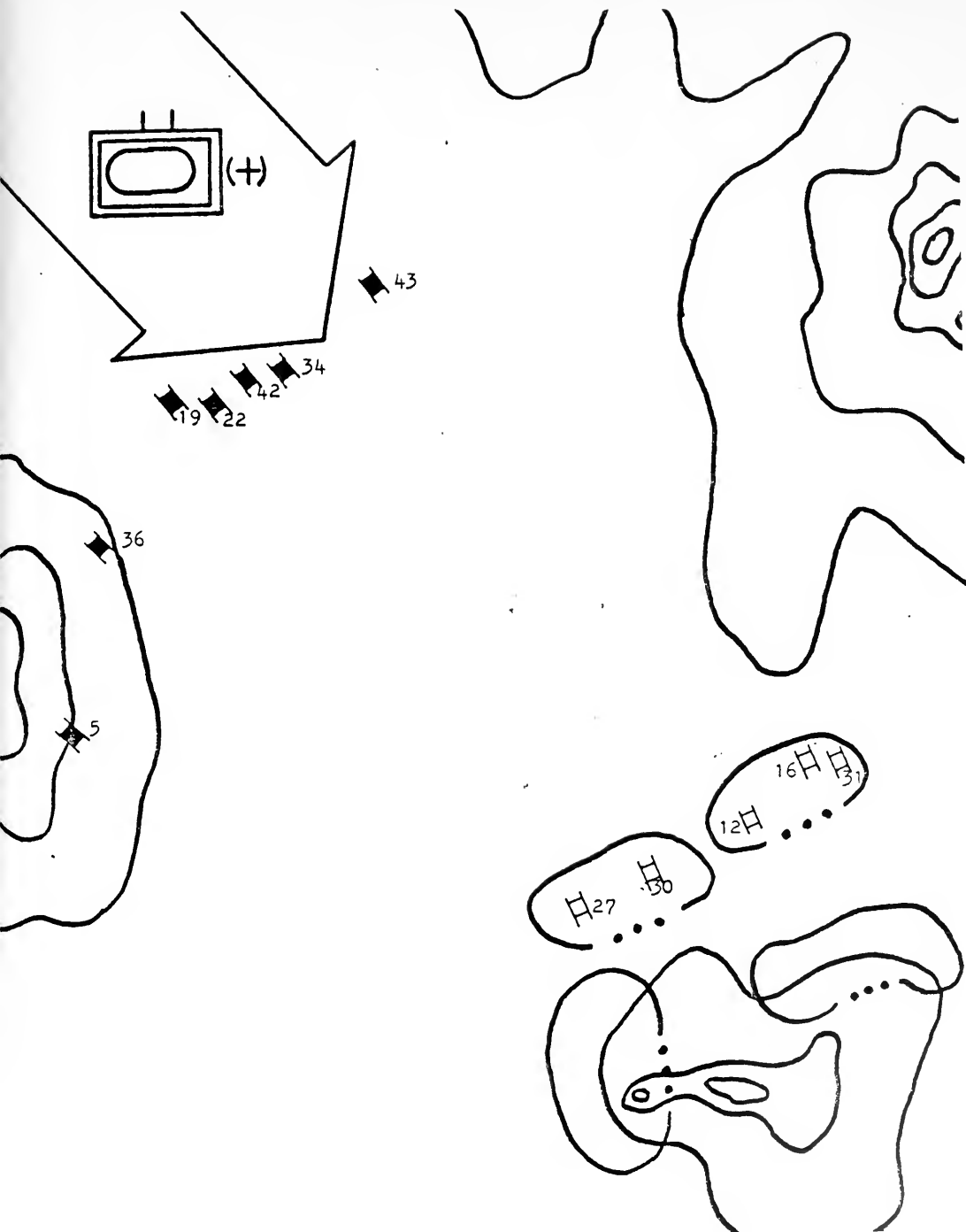


Figure 6



Simulated time 106.3 thru 133.9 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 47  | 82  | BMP  | 1  | 8   | XM1  | 106.3  | HIDE | 2728  | 7822  | 6612  | 5200  | 5860  |
| 48  | 67  | BMP  | 1  | 2   | XM1  | 107.4  |      | 2930  | 7272  | 7172  | 4970  | 5360  |
| 49  | 68  | T72  | 1  | 11  | XM1  | 109.3  |      | 2482  | 7834  | 6484  | 5760  | 5120  |
| 50  | 21  | ITV  | 1  | 57  | T72  | 110.4  | DEAD | 2802  | 5000  | 5100  | 6900  | 7160  |
| 51  | 11  | XM1  | 1  | 72  | T72  | 112.3  |      | 2256  | 5760  | 5120  | 7503  | 6553  |
| 52  | 22  | ITV  | 1  | 54  | T72  | 114.2  | DEAD | 2850  | 4920  | 5100  | 6736  | 7296  |
| 53  | 23  | ITV  | 1  | 61  | T72  | 114.9  |      | 2832  | 4700  | 5450  | 7134  | 6899  |
| 54  | 75  | T72  | 1  | 10  | XM1  | 115.6  |      | 2262  | 7691  | 6361  | 5710  | 5270  |
| 55  | 77  | T72  | 1  | 4   | XM1  | 119.0  |      | 2527  | 7779  | 6179  | 5300  | 5690  |
| 56  | 70  | T72  | 1  | 10  | XM1  | 119.6  |      | 2163  | 7378  | 6648  | 5710  | 5270  |
| 57  | 14  | IFV  | 1  | 61  | T72  | 119.7  | DEAD | 2849  | 5090  | 4880  | 7117  | 6882  |
| 58  | 64  | BMP  | 1  | 1   | XM1  | 120.5  | DEAD | 2859  | 7040  | 7440  | 4940  | 5500  |
| 59  | 27  | IFV  | 1  | 44  | T72  | 120.7  | DEAD | 2649  | 4640  | 5630  | 6493  | 7523  |
| 60  | 63  | T72  | 1  | 4   | XM1  | 120.8  |      | 2216  | 7233  | 6773  | 5300  | 5690  |
| 61  | 26  | IFV  | 1  | 45  | T72  | 121.5  | DEAD | 2781  | 4530  | 5570  | 6541  | 7491  |
| 62  | 53  | T72  | 1  | 5   | XM1  | 121.5  |      | 2293  | 6646  | 7346  | 5400  | 5420  |
| 63  | 28  | IFV  | 1  | 41  | T72  | 122.3  | DEAD | 2623  | 4760  | 5600  | 6348  | 7688  |
| 64  | 5   | XM1  | 1  | 72  | T72  | 126.6  | DEAD | 2320  | 5400  | 5420  | 7452  | 6502  |
| 65  | 69  | T72  | 1  | 4   | XM1  | 128.8  | DEAD | 2198  | 7275  | 6655  | 5300  | 5690  |
| 66  | 65  | BMP  | 1  | 3   | ITV  | 129.4  | DEAD | 2820  | 7049  | 7319  | 4910  | 5480  |
| 67  | 10  | XM1  | 1  | 69  | T72  | 131.6  | DEAD | 2075  | 5710  | 5270  | 7265  | 6645  |
| 68  | 56  | T72  | 1  | 2   | XM1  | 133.2  |      | 2530  | 6749  | 7159  | 4970  | 5360  |
| 69  | 24  | ITV  | 1  | 42  | T72  | 133.8  | DEAD | 2759  | 4650  | 5430  | 6357  | 7597  |
| 70  | 73  | T72  | 1  | 10  | XM1  | 133.9  |      | 2120  | 7486  | 6426  | 5710  | 5270  |

BLUE Elements Remaining at 133.9 seconds

| Wpn Type | Number<br>at Start | Number<br>remaining | Average Rnds per Wpn<br>remaining  |
|----------|--------------------|---------------------|------------------------------------|
| XM1      | 12                 | 5                   | 21 APDS, 15.6 HEAT,<br>1000 cal 50 |
| IFV      | 8                  | 8                   | 5 TOW, 1000 Bushmaster             |
| ITV      | 4                  | 4                   | 6.75 TOW                           |
| DRAGON   | 6                  | 6                   | 6 DRAGON                           |

RED Elements Remaining at 133.9 seconds

| Wpn Type | Number<br>at Start | Number<br>remaining | Average Rnds per Wpn<br>remaining   |
|----------|--------------------|---------------------|-------------------------------------|
| T72      | 40                 | 24                  | 21.42 APDS, 18 HEAT,<br>1000 12.7mm |
| BMP      | 13                 | 13                  | 7.31 SAGGER, 40 73mm                |



Priority target for all weapon systems continues to be the opposing tank forces. Each of the two BLUE tank platoons is reduced to two tanks. In addition, one of the headquarters tanks of the defending team is destroyed.

Note that at rounds 66, ITV number 3 was destroyed. This vehicle is listed as an ITV for lethality purposes, but in fact, is the F0 vehicle.

Note also that during the first 133 seconds of the simulation the attacking tank force is reduced to 60% of its original strength.





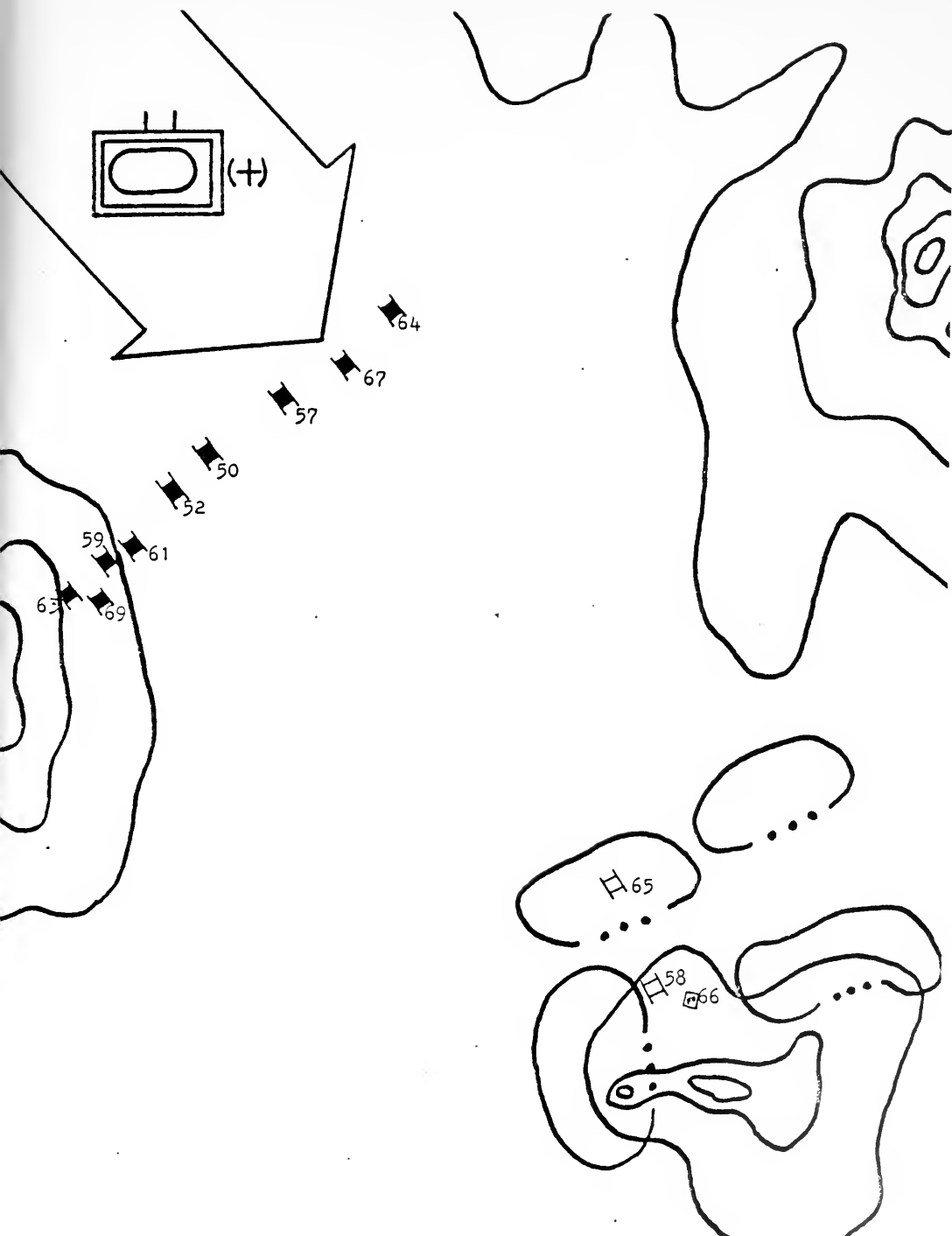


Figure 7



Simulated time 135.4 thru 158.7 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 71  | 79  | T72  | 1  | 10  | XM1  | 135.4  |      | 2282  | 7871  | 6001  | 5710  | 5270  |
| 72  | 67  | BMP  | 1  | 2   | XM1  | 135.6  | DEAD | 2832  | 7203  | 7103  | 4970  | 5360  |
| 73  | 15  | IFV  | 1  | 69  | T72  | 136.1  | DEAD | 2819  | 5150  | 4780  | 7265  | 6645  |
| 74  | 63  | T72  | 1  | 10  | XM1  | 137.0  |      | 2059  | 7176  | 6716  | 5710  | 5270  |
| 75  | 66  | BMP  | 1  | 27  | IFV  | 138.0  | DEAD | 2908  | 7120  | 7150  | 4640  | 5630  |
| 76  | 77  | T72  | 1  | 10  | XM1  | 138.2  | DEAD | 2171  | 7711  | 6111  | 5710  | 5270  |
| 77  | 21  | ITV  | 1  | 55  | T72  | 138.4  | DEAD | 2678  | 5000  | 5100  | 6681  | 7186  |
| 78  | 53  | T72  | 1  | 5   | XM1  | 140.1  | DEAD | 2202  | 6570  | 7280  | 5400  | 5420  |
| 79  | 5   | XM1  | 1  | 56  | T72  | 140.2  |      | 2166  | 5400  | 5420  | 6724  | 7134  |
| 80  | 81  | BMP  | 1  | 5   | XM1  | 141.9  | DEAD | 2508  | 7643  | 6543  | 5400  | 5420  |
| 81  | 22  | ITV  | 1  | 53  | T72  | 143.0  | DEAD | 2725  | 4920  | 5100  | 6570  | 7270  |
| 82  | 8   | XM1  | 2  | 67  | BMP  | 144.9  |      | 2294  | 5200  | 5860  | 7157  | 7057  |
| 83  | 14  | IFV  | 1  | 70  | T72  | 150.7  | DEAD | 2736  | 5099  | 4880  | 7267  | 6537  |
| 84  | 8   | XM1  | 2  | 67  | BMP  | 153.2  |      | 2237  | 5200  | 5860  | 7115  | 7015  |
| 85  | 26  | IFV  | 1  | 43  | T72  | 154.1  | DEAD | 2624  | 4530  | 5570  | 6355  | 7455  |
| 86  | 32  | T72  | 1  | 11  | XM1  | 154.6  |      | 2514  | 7073  | 7263  | 5760  | 5120  |
| 87  | 28  | IFV  | 1  | 63  | T72  | 155.4  | DEAD | 2575  | 4760  | 5600  | 7110  | 6650  |
| 88  | 11  | XM1  | 1  | 76  | T72  | 156.0  |      | 2107  | 5760  | 5120  | 7599  | 6149  |
| 89  | 68  | T72  | 1  | 11  | XM1  | 157.8  |      | 2245  | 7662  | 6312  | 5760  | 5120  |
| 90  | 51  | T72  | 1  | 11  | XM1  | 158.3  |      | 2447  | 6890  | 7290  | 5760  | 5120  |
| 91  | 82  | BMP  | 1  | 11  | XM1  | 158.7  |      | 2263  | 7619  | 6409  | 5760  | 5120  |

BLUE Elements Remaining at 158.7 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| XM1             | 12                     | 2                       | 21 APDS, 14 HEAT, 1000 cal 50         |
| IFV             | 8                      | 7                       | 4.71 TOW, 1000 Bushmaster             |
| ITV             | 4                      | 4                       | 6.25 TOW                              |
| DRAGON          | 6                      | 6                       | 6 DRAGON                              |

RED Elements Remaining at 158.7 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| T72             | 40                     | 19                      | 20.21 APDS, 18 HEAT, 1000 cal 50      |
| BMP             | 13                     | 13                      | 7 SAGGER, 40 73mm                     |



Red tank systems continue to be the priority target for BLUE systems and continue to be attritted significantly. To this point in the battle no BMPs have been eliminated from the attacking force. Note that T72 number 69 (round 73) was previously destroyed at round 67. Round 73 is the impact of a TOW round fired by an IFV. The impact of this second round on T72 number 69 is largely a consequence of the long time of flight of the TOW round which was actually fired prior to the impact of round 67.

The BLUE defenders have been reduced to only two tanks, one in each of the tank platoons. The reduction in the number of defending tanks should cause IFV and ITV systems to become the priority target for the attackers.



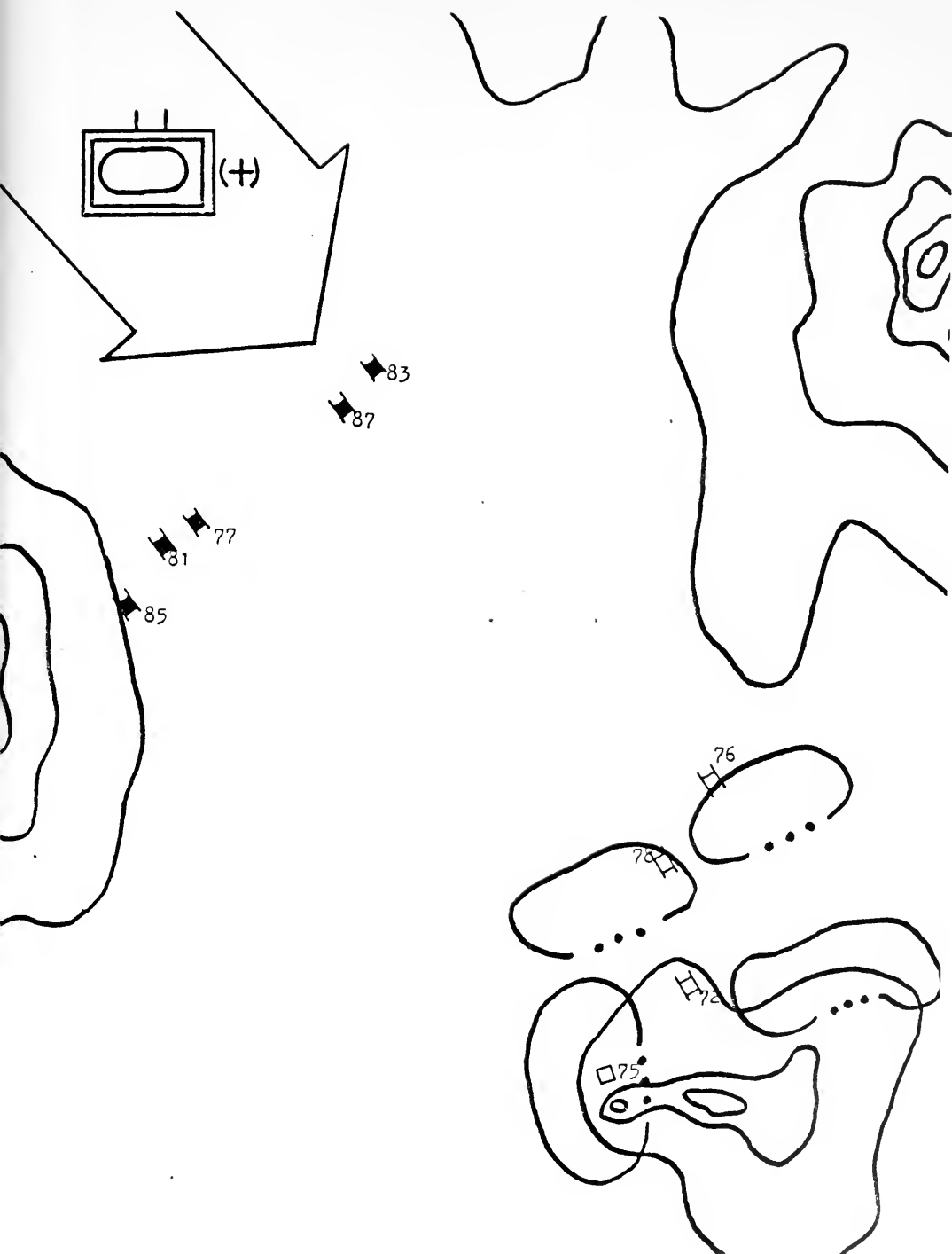


Figure 8





Simulated time 161.7 thru 201.9 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 92  | 23  | ITV  | 1  | 39  | T72  | 161.7  | DEAD | 2630  | 4700  | 5450  | 6048  | 7708  |
| 93  | 11  | XM1  | 1  | 76  | T72  | 162.8  | DEAD | 2074  | 5760  | 5120  | 7574  | 6124  |
| 94  | 65  | BMP  | 1  | 21  | ITV  | 163.3  | DEAD | 2883  | 6952  | 7222  | 5000  | 5100  |
| 95  | 66  | BMP  | 1  | 28  | IFV  | 163.9  | DEAD | 2739  | 7059  | 7089  | 4760  | 5600  |
| 96  | 16  | IFV  | 1  | 75  | T72  | 164.2  | DEAD | 2835  | 5120  | 4680  | 7520  | 6190  |
| 97  | 64  | BMP  | 1  | 11  | XM1  | 165.0  | HIDE | 2434  | 6880  | 7280  | 5760  | 5120  |
| 98  | 21  | ITV  | 1  | 63  | T72  | 165.6  | DEAD | 2619  | 5000  | 5100  | 7110  | 6650  |
| 99  | 15  | IFV  | 1  | 73  | T72  | 166.6  | DEAD | 2697  | 5150  | 4780  | 7371  | 6311  |
| 100 | 67  | BMP  | 1  | 23  | ITV  | 179.6  | DEAD | 2794  | 7054  | 6954  | 4700  | 5450  |
| 101 | 26  | IFV  | 1  | 40  | T72  | 182.6  | DEAD | 2502  | 4530  | 5570  | 6054  | 7554  |
| 102 | 22  | ITV  | 1  | 56  | T72  | 186.2  | DEAD | 2489  | 4920  | 5100  | 6562  | 6972  |
| 103 | 82  | BMP  | 1  | 22  | ITV  | 187.9  | DEAD | 2903  | 7546  | 6336  | 4920  | 5100  |
| 104 | 16  | IFV  | 1  | 77  | T72  | 189.5  | DEAD | 2715  | 5120  | 4680  | 7530  | 5930  |
| 105 | 8   | XM1  | 1  | 68  | T72  | 189.8  |      | 2373  | 5200  | 5860  | 7549  | 6199  |
| 106 | 14  | IFV  | 1  | 74  | T72  | 193.7  | DEAD | 2572  | 5090  | 4880  | 7335  | 6135  |
| 107 | 50  | BMP  | 1  | 22  | ITV  | 194.7  | DEAD | 2838  | 6242  | 7612  | 4920  | 5100  |
| 108 | 66  | BMP  | 1  | 26  | IFV  | 194.8  | DEAD | 2837  | 6976  | 7006  | 4530  | 5570  |
| 109 | 65  | BMP  | 1  | 22  | ITV  | 196.1  | DEAD | 2807  | 6859  | 7129  | 4920  | 5100  |
| 110 | 8   | XM1  | 1  | 68  | T72  | 197.5  |      | 2342  | 5200  | 5860  | 7522  | 6172  |
| 111 | 11  | XM1  | 1  | 32  | T72  | 201.9  |      | 2285  | 5760  | 5120  | 6906  | 7096  |

BLUE elements remaining at 201.9 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| XM1             | 12                     | 2                       | 19 APDS, 14 HEAT,<br>1000 cal 50      |
| IFV             | 8                      | 5                       | 4.4 TOW, 1000 Bushmaster              |
| ITV             | 4                      | 1                       | 7 TOW                                 |
| DRAGON          | 6                      | 6                       | 6 DRAGON                              |

RED elements remaining at 201.9 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| T72             | 40                     | 11                      | 21.45 APDS, 18 HEAT,<br>1000 12.7mm   |
| BMP             | 13                     | 13                      | 6.38 SAGGER, 40 73mm                  |

At this point in the simulation, BLUE long range systems have been attrited significantly. Each of the tank platoons has one remaining vehicle. One of the Mech platoons has been reduced to only 1 IFV and 3 DRAGON teams, and there



remains only one operational ITV in the simulation. The battle has become virtually a SAGGER versus TOW duel.

BLUE weapons continue to target attacking tanks, while the scarcity of BLUE tanks make the IFV and ITV priority targets for the attackers.



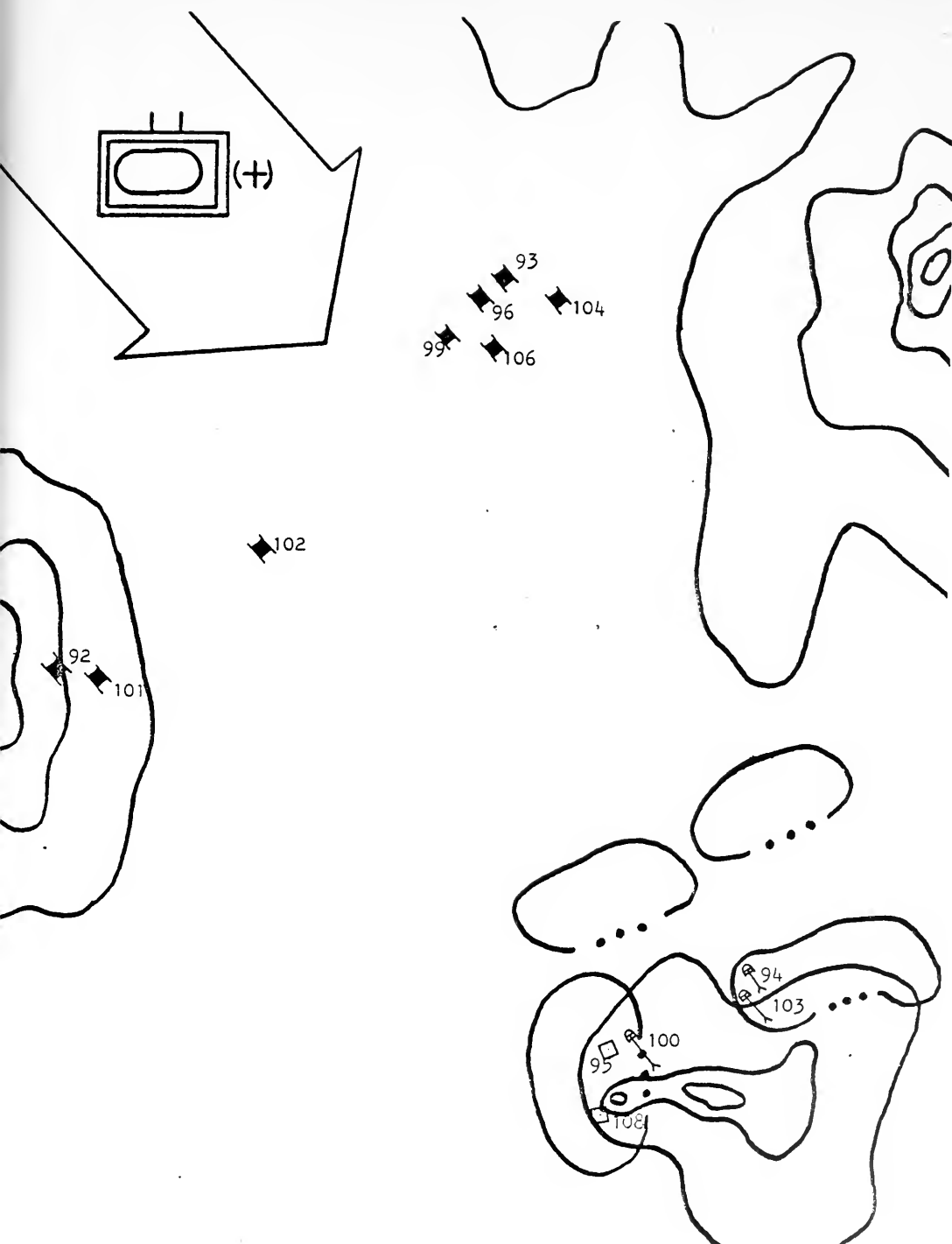


Figure 9



Simulated time 203.8 thru 272.8 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 112 | 51  | T72  | 1  | 11  | XM1  | 203.8  | DEAD | 2231  | 6730  | 7130  | 5760  | 5120  |
| 113 | 24  | ITV  | 1  | 32  | T72  | 209.8  | DEAD | 2766  | 4650  | 5430  | 6878  | 7068  |
| 114 | 67  | BMP  | 1  | 24  | ITV  | 210.3  | DEAD | 2730  | 6969  | 6869  | 4650  | 5430  |
| 115 | 81  | BMP  | 1  | 24  | ITV  | 210.7  | DEAD | 2850  | 7372  | 6272  | 4650  | 5430  |
| 116 | 82  | BMP  | 1  | 14  | IFV  | 215.0  | DEAD | 2766  | 7481  | 6271  | 5090  | 4880  |
| 117 | 17  | IFV  | 1  | 68  | T72  | 215.3  | DEAD | 2833  | 5100  | 4540  | 7459  | 6109  |
| 118 | 15  | IFV  | 1  | 51  | T72  | 215.8  | DEAD | 2772  | 5150  | 4780  | 6687  | 7087  |
| 119 | 16  | IFV  | 1  | 81  | BMP  | 219.5  | DEAD | 2698  | 5120  | 4680  | 7329  | 6229  |
| 120 | 49  | BMP  | 1  | 14  | IFV  | 219.8  | DEAD | 2916  | 6075  | 7625  | 5090  | 4880  |
| 121 | 14  | IFV  | 1  | 78  | T72  | 222.0  | .    | 2563  | 5090  | 4880  | 7485  | 5765  |
| 122 | 65  | BMP  | 1  | 14  | IFV  | 223.4  | DEAD | 2768  | 6793  | 7063  | 5090  | 4880  |
| 123 | 8   | XM1  | 2  | 67  | BMP  | 234.2  |      | 1876  | 5200  | 5860  | 6851  | 6751  |
| 124 | 82  | BMP  | 1  | 16  | IFV  | 241.1  | DEAD | 2762  | 7420  | 6210  | 5120  | 4680  |
| 125 | 78  | T72  | 1  | 8   | XM1  | 242.4  |      | 2229  | 7423  | 5693  | 5200  | 5860  |
| 126 | 8   | XM1  | 2  | 67  | BMP  | 245.6  |      | 1823  | 5200  | 5860  | 6812  | 6712  |
| 127 | 15  | IFV  | 1  | 84  | BMP  | 246.3  | DEAD | 2555  | 5150  | 4780  | 7479  | 5829  |
| 128 | 16  | IFV  | 1  | 82  | BMP  | 248.4  |      | 2712  | 5120  | 4680  | 7384  | 6174  |
| 129 | 67  | BMP  | 1  | 8   | XM1  | 251.3  | HIDE | 1823  | 6812  | 6712  | 5200  | 5860  |
| 130 | 82  | BMP  | 1  | 15  | IFV  | 272.8  |      | 2554  | 7326  | 6116  | 5150  | 4780  |

BLUE elements remaining at 272.8 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| XM1             | 12                     | 1                       | 21 APDS, 10 HEAT,<br>1000 cal 50      |
| IFV             | 8                      | 3                       | 3.33 TOW, 1000<br>Bushmaster          |
| ITV             | 4                      | 0                       | -----                                 |
| DRAGON          | 6                      | 6                       | 6 DRAGON                              |

RED elements remaining at 272.8 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| T72             | 40                     | 8                       | 21.63 APDS, 18 HEAT,<br>1000 12.7mm   |
| BMP             | 13                     | 11                      | 5.54 SAGGER, 40 73mm                  |





At this point in the simulation, the BLUE force has been reduced to 1 tank, 3 IFVs, and 6 DRAGON teams. The RED tank force has been reduced significantly, but the attacking BMP force remains essentially intact.

Available TOW ammunition has been reduced to only 10 rounds available to the defending force. IFVs number 15 and 17 have two rounds each, while IFV number 25 has 6 TOWs remaining. All defending ITVs have been destroyed.



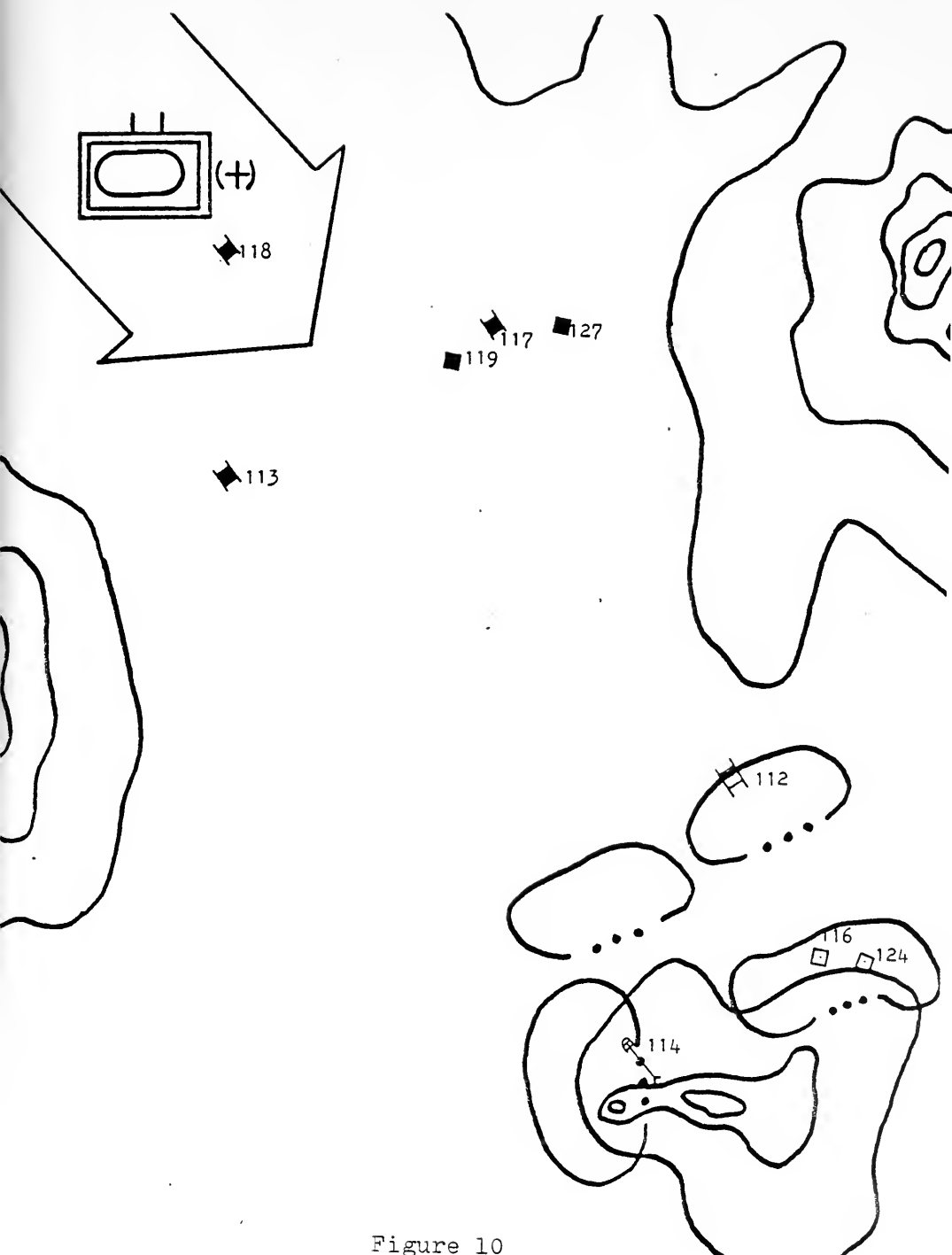


Figure 10



Simulated time 277.5 thru 399.6 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 131 | 15  | IFV  | 1  | 65  | BMP  | 277.5  | DEAD | 2304  | 5150  | 4780  | 6567  | 6597  |
| 132 | 8   | XM1  | 1  | 35  | T72  | 285.7  |      | 1732  | 5200  | 5860  | 5290  | 7590  |
| 133 | 35  | T72  | 1  | 8   | XM1  | 285.8  |      | 1732  | 5290  | 7590  | 5200  | 5860  |
| 134 | 8   | XM1  | 1  | 35  | T72  | 292.7  |      | 1706  | 5200  | 5860  | 5265  | 7565  |
| 135 | 83  | BMP  | 1  | 8   | XM1  | 298.3  | HIDE | 2083  | 7282  | 5782  | 5200  | 5860  |
| 136 | 82  | BMP  | 1  | 15  | IFV  | 298.4  | DEAD | 2463  | 7260  | 6050  | 5150  | 4780  |
| 137 | 15  | IFV  | 1  | 67  | BMP  | 308.5  |      | 2149  | 5150  | 4780  | 6528  | 6428  |
| 138 | 50  | BMP  | 3  | 30  | DRAG | 312.8  | DEAD | 1713  | 5657  | 7027  | 4550  | 5720  |
| 139 | 64  | BMP  | 3  | 18  | DRAG | 313.1  |      | 1745  | 6147  | 6547  | 5840  | 4830  |
| 140 | 67  | BMP  | 3  | 31  | DRAG | 315.5  |      | 1906  | 6494  | 6394  | 4700  | 5750  |
| 141 | 36  | T72  | 3  | 31  | DRAG | 316.5  | DEAD | 1750  | 5281  | 7401  | 4700  | 5750  |
| 142 | 48  | BMP  | 3  | 31  | DRAG | 316.7  | DEAD | 1834  | 5540  | 7380  | 4700  | 5750  |
| 143 | 33  | BMP  | 3  | 18  | DRAG | 327.5  |      | 1897  | 6542  | 6592  | 5840  | 4830  |
| 144 | 64  | BMP  | 3  | 18  | DRAG | 331.9  |      | 1638  | 6054  | 6454  | 5840  | 4830  |
| 145 | 65  | BMP  | 3  | 19  | DRAG | 332.6  |      | 1841  | 6252  | 6522  | 5790  | 4740  |
| 146 | 83  | BMP  | 1  | 8   | XM1  | 343.8  | DEAD | 1922  | 7105  | 5605  | 5200  | 5860  |
| 147 | 65  | BMP  | 3  | 19  | DRAG | 344.3  |      | 1771  | 6194  | 6464  | 5790  | 4740  |
| 148 | 67  | BMP  | 3  | 20  | DRAG | 345.8  | DEAD | 1703  | 6344  | 6244  | 5670  | 4680  |
| 149 | 64  | BMP  | 3  | 18  | DRAG | 346.6  |      | 1558  | 5981  | 6381  | 5840  | 4830  |
| 150 | 33  | BMP  | 1  | 8   | XM1  | 350.0  | DEAD | 1456  | 6488  | 6538  | 5200  | 5860  |
| 151 | 65  | BMP  | 3  | 19  | DRAG | 364.6  | DEAD | 1652  | 6084  | 6364  | 5790  | 4740  |
| 152 | 64  | BMP  | 3  | 18  | DRAG | 366.8  |      | 1452  | 5881  | 6281  | 5840  | 4830  |
| 153 | 33  | BMP  | 3  | 18  | DRAG | 369.9  |      | 1701  | 6390  | 6440  | 5840  | 4830  |
| 154 | 64  | BMP  | 3  | 18  | DRAG | 387.2  |      | 1352  | 5780  | 6180  | 5840  | 4830  |
| 155 | 33  | BMP  | 3  | 18  | DRAG | 390.3  |      | 1574  | 6289  | 6339  | 5840  | 4830  |
| 156 | 64  | BMP  | 3  | 18  | DRAG | 399.6  |      | 1295  | 5719  | 6119  | 5840  | 4830  |

BLUE elements remaining at 399.6 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| XM1             | 12                     | 0                       | -----                                 |
| IFV             | 8                      | 2                       | 4 TOW, 1000 Bushmaster                |
| ITV             | 4                      | 0                       | -----                                 |
| DRAGON          | 6                      | 2                       | 6 DRAGON                              |

RED elements remaining at 399.6 seconds

| <u>Wpn Type</u> | <u>Number at Start</u> | <u>Number remaining</u> | <u>Average Rnds per Wpn remaining</u> |
|-----------------|------------------------|-------------------------|---------------------------------------|
| T72             | 40                     | 8                       | 21.5 APDS, 18 HEAT,<br>998 12.7mm     |
| BMP             | 13                     | 10                      | 5.3 SAGGER, 38.4 73mm                 |



At this point in the simulation, the BLUE tank force and ITVs have been eliminated. Each of the Mech platoons has one IFV and one DRAGON team remaining. The lack of BLUE weapon systems remaining in the simulation has caused the DRAGON teams to assume highest priority in the target lists of some of the attackers. The DRAGONS are being engaged at ranges beyond 1000 meters and thus are unable to return fire. Note that DRAGONS are being engaged by ammunition type 3 (73mm for BMPs and 12.7mm for T72s).

Note also at round 136 that IFV number 15 is destroyed, but at this time he has a TOW round in flight which impacts at round 137. The model takes into account the fact that a wire guided round is "unguided" when its carrier is destroyed, and although the round impacts it will always be assessed as a miss.







Figure 11



Simulated time 402.3 thru 750.0 seconds

| RND | FIR | TYPE | AM | TGT | TYPE | TIME.V | STAT | RANGE | X-FIR | Y-FIR | X-TGT | Y-TGT |
|-----|-----|------|----|-----|------|--------|------|-------|-------|-------|-------|-------|
| 157 | 33  | BMP  | 3  | 18  | DRAG | 402.3  | DEAD | 1501  | 6230  | 6280  | 5840  | 4830  |
| 158 | 17  | IFV  | 1  | 78  | T72  | 490.8  | DEAD | 1470  | 5100  | 4540  | 6545  | 4815  |
| 159 | 80  | T72  | 2  | 17  | IFV  | 498.1  |      | 1579  | 6676  | 4626  | 5100  | 4540  |
| 160 | 79  | T72  | 2  | 17  | IFV  | 498.7  | DEAD | 1505  | 6594  | 4724  | 5100  | 4540  |
| 161 | 29  | DRAG | 2  | 36  | T72  | 563.8  | DEAD | 887   | 4430  | 5640  | 4407  | 6527  |
| 162 | 29  | DRAG | 2  | 37  | T72  | 578.8  | DEAD | 754   | 4430  | 5640  | 4394  | 6394  |
| 163 | 25  | IFV  | 3  | 49  | BMP  | 586.3  | DEAD | 292   | 4370  | 5540  | 4260  | 5810  |
| 164 | 25  | IFV  | 3  | 50  | BMP  | 612.3  | DEAD | 195   | 4370  | 5540  | 4175  | 5545  |
| 165 | 25  | IFV  | 1  | 35  | T72  | 631.8  | DEAD | 880   | 4370  | 5540  | 4066  | 6366  |
| 166 | 25  | IFV  | 1  | 38  | T72  | 650.6  | DEAD | 524   | 4370  | 5540  | 4250  | 6050  |
| 167 | 25  | IFV  | 3  | 48  | BMP  | 686.7  | DEAD | 550   | 4370  | 5540  | 4232  | 6072  |
| 168 | 25  | IFV  | 3  | 47  | BMP  | 705.2  |      | 616   | 4370  | 5540  | 4087  | 6087  |
| 169 | 25  | IFV  | 3  | 47  | BMP  | 721.7  |      | 596   | 4370  | 5540  | 4028  | 6028  |
| 170 | 25  | IFV  | 3  | 47  | BMP  | 738.4  |      | 587   | 4370  | 5540  | 3969  | 5969  |

SIMULATION STOPPED AT 750.000 LOS CALLS = 4696

BLUE elements remaining at 750.0 seconds

| Wpn Type | Number<br>at Start | Number<br>remaining | Average Rnds per Wpn<br>remaining |
|----------|--------------------|---------------------|-----------------------------------|
| XM1      | 12                 | 0                   | -----                             |
| IFV      | 8                  | 1                   | 4 TOW, 940 Bushmaster             |
| ITV      | 4                  | 0                   | -----                             |
| DRAGON   | 6                  | 1                   | 4 DRAGON                          |

RED elements remaining at 750.0 seconds

| Wpn Type | Number<br>at Start | Number<br>remaining | Average Rnds per Wpn<br>remaining      |
|----------|--------------------|---------------------|--|
| T72      | 40                 | 3                   | 21.33 APDS, 17.33 HEAT,<br>1000 12.7mm |
| BMP      | 13                 | 7                   | 4.43 SAGGER, 37.85 73mm                |

At termination of the simulation, one IFV and one DRAGON team remain of the BLUE force, while three T72s and seven BMPs remain of the RED force.



The attacking force had closed to a range where the DRAGON was able to bring effective fire on the RED force. Notice that at these reduced ranges the IFV continues to engage T72s with ammunition type 1 (TOW), but selects ammunition type 3 (Bushmaster) to fire at the thinner skinned BMPs.

The attacking force remains oriented toward its direction of movement, and thus never "sees" the remaining defenders as they pass the BLUE positions. This enables the defenders to destroy several RED vehicles during the last few minutes of the simulation without drawing any significant answering fires.



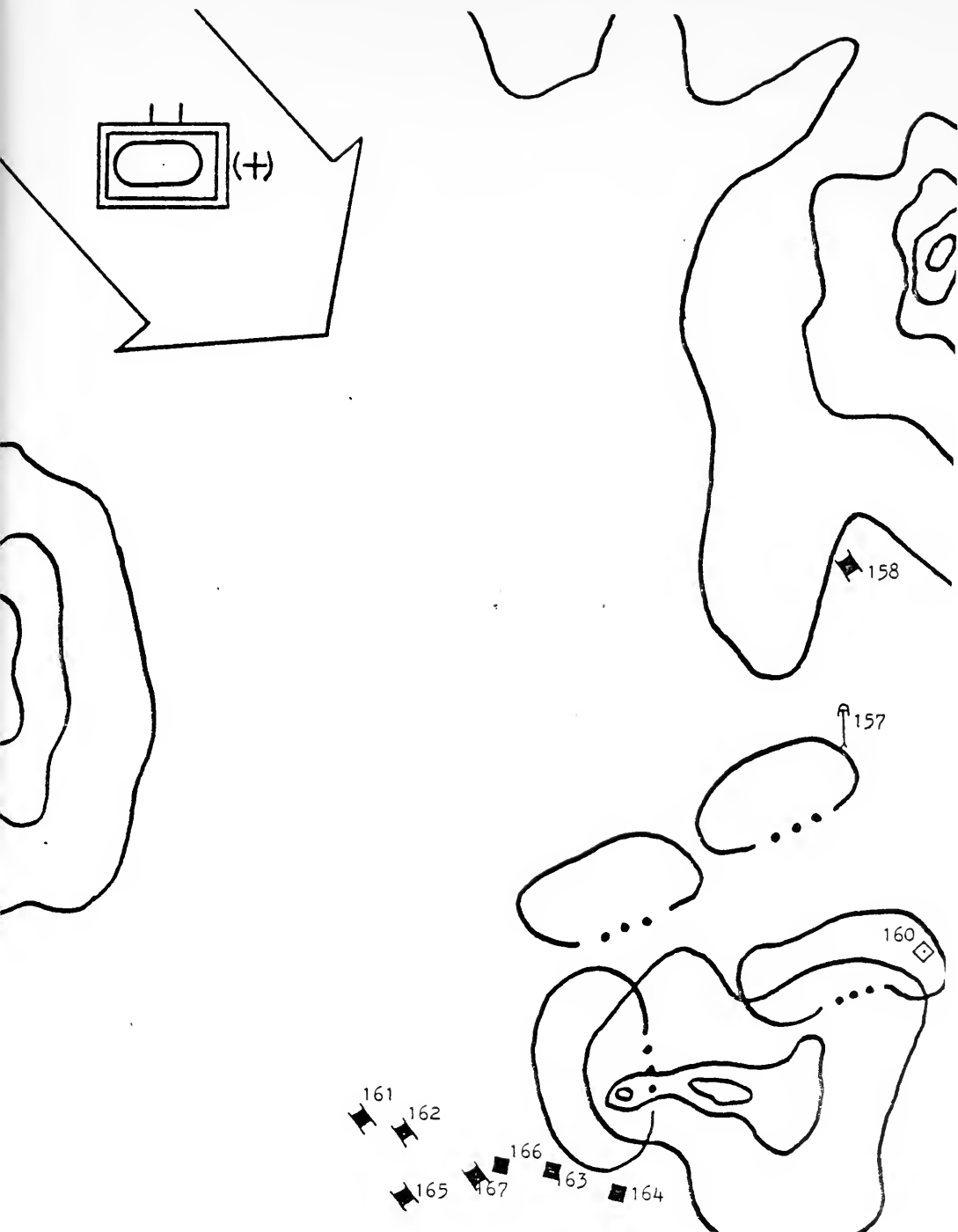


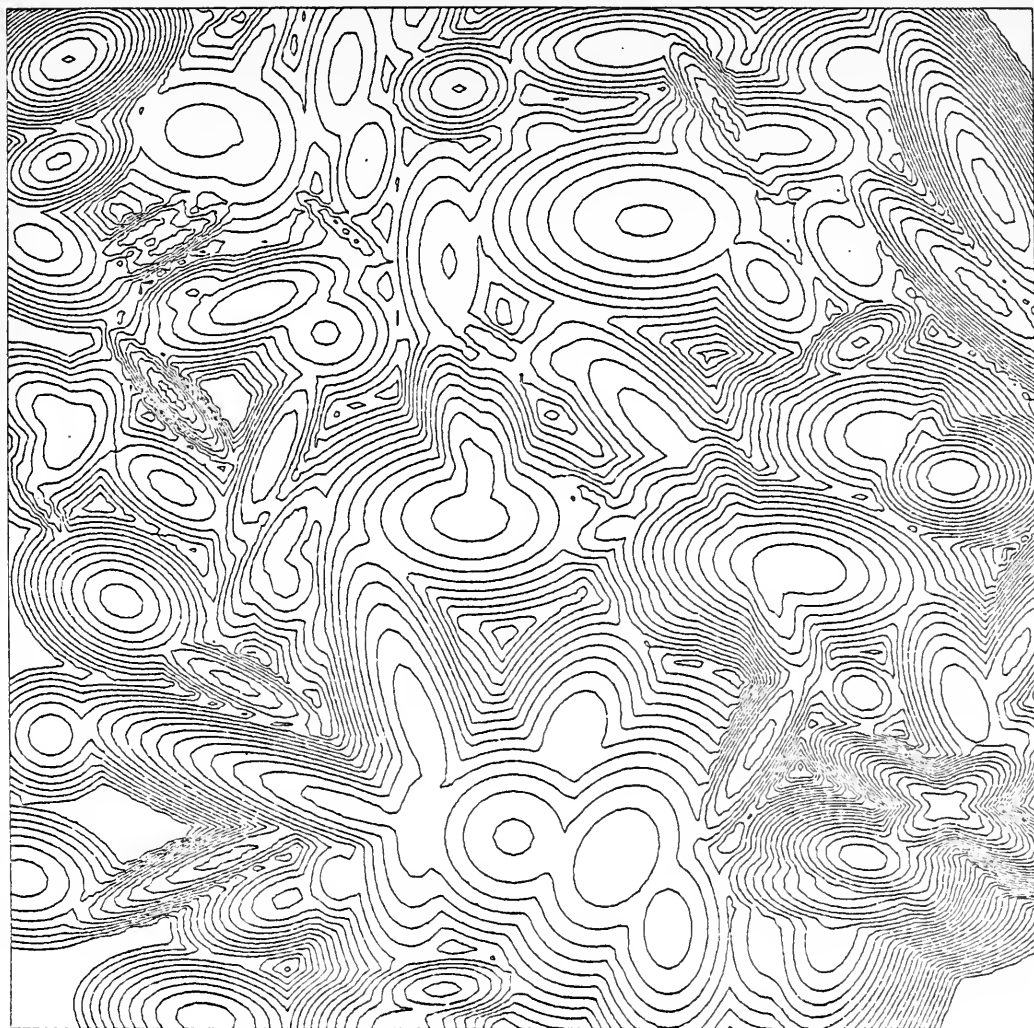
Figure 12





The reader is cautioned not to draw any analytical conclusions from the preceding simulation. This simulation was run to demonstrate the capabilities of the STAR model. The data used for the exercise was greatly simplified and in no way represents what might be the results of the model run in support of a particular study.





Versatec Plot of Parametric Terrain

Figure 13



## VII. FUTURE MODEL ENHANCEMENT

The model described in the preceding chapters should not be viewed as the final product. Enhancement of the existing model is the subject of several masters degree theses currently under development at the Naval Postgraduate School. The purpose of this chapter is to give the reader a general idea of projected additions to the model.

As mentioned in Chapter I, a close air support/air defense module is under development for inclusion in the model. The availability of this module is projected to be mid-April 1979. In addition, a working artillery module is now available, and will be integrated into the model by mid-December 1978.

The criteria for target selection using the danger state arrays is not considered sufficient for future model uses. It is possible that the interaction of such factors as ammunition remaining, whether an enemy element has fired, anticipated time of ammunition resupply, etc., could alter the priorities calculated from the danger state arrays. Research is currently being conducted to determine what additional factors are important in target selection and how these factors should be included in target selection logic.

Ammunition and fuel redistribution and resupply are considered vital to the success of any military operation.



Future versions of the model will include resupply of fuel and ammunition to include the introduction of resupply vehicles to the simulation to allow dynamic resupply to be played.

A Battalion communication model is currently under development which will incorporate electronic warfare considerations. This model will contain a realistic propagation model, incomplete transmission detection and retransmission, frequency change effects, play of message traffic and play of RED intercept and jamming.

Dynamic route selection is being considered for future model inclusion. A module which considers enemy locations, the terrain, and the tactical situation, and dynamically computes routes for elements has been proposed to enhance the existing model. This module would be a user specified option and would allow pre-selection of routes or dynamic selection of routes as desired by the user.

It is difficult to predict when all of the above mentioned modules will be available for integration into the STAR model. It is intended that enhancement of the model be a continuing effort at the Naval Postgraduate School, the objective of which is to provide a versatile mid-resolution combat model for a wide variety of military applications.





## APPENDIX A

### FLOWCHART

This appendix presents the event sequence a single XML would follow through the model.

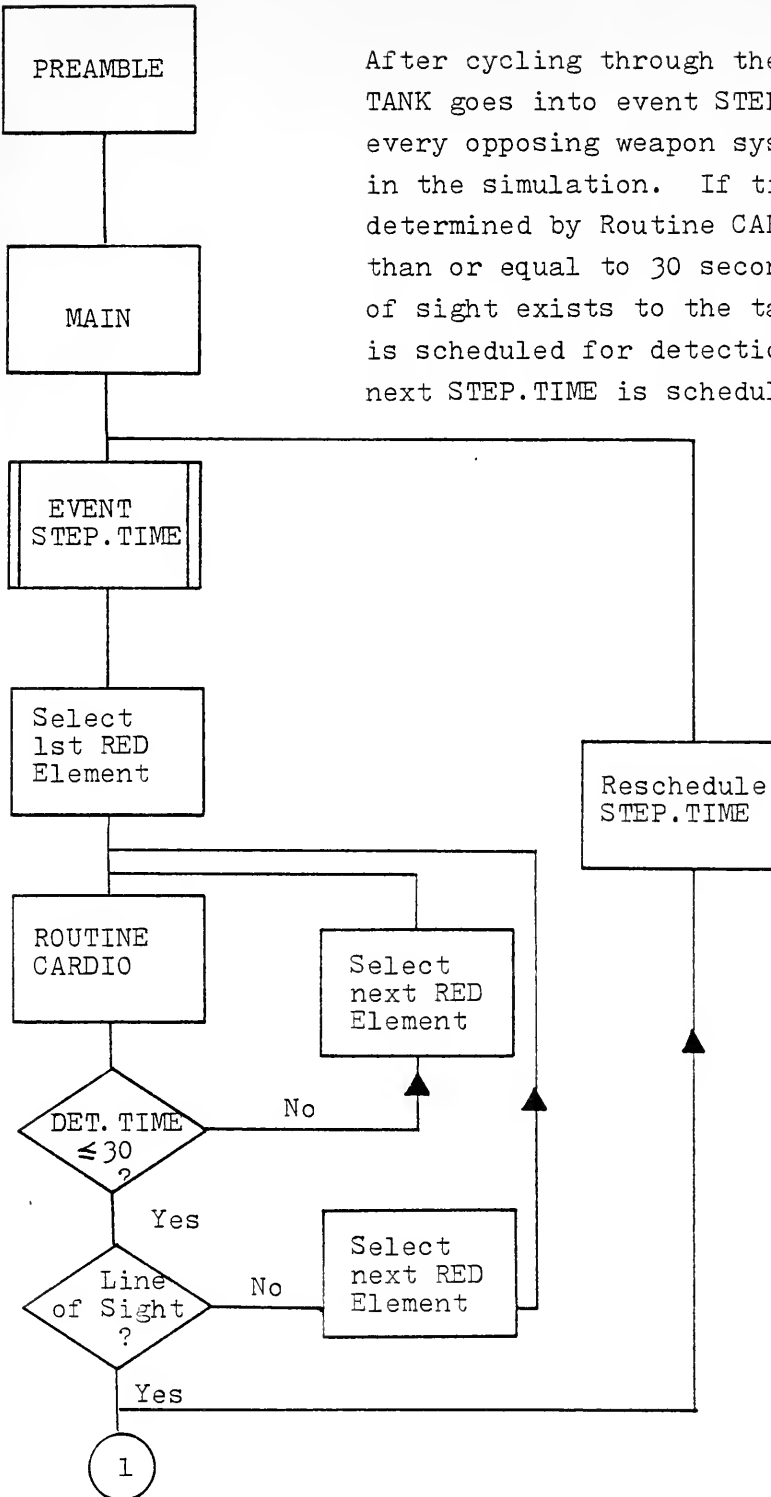
Within the flowchart the following non-standard symbol is used:



an event

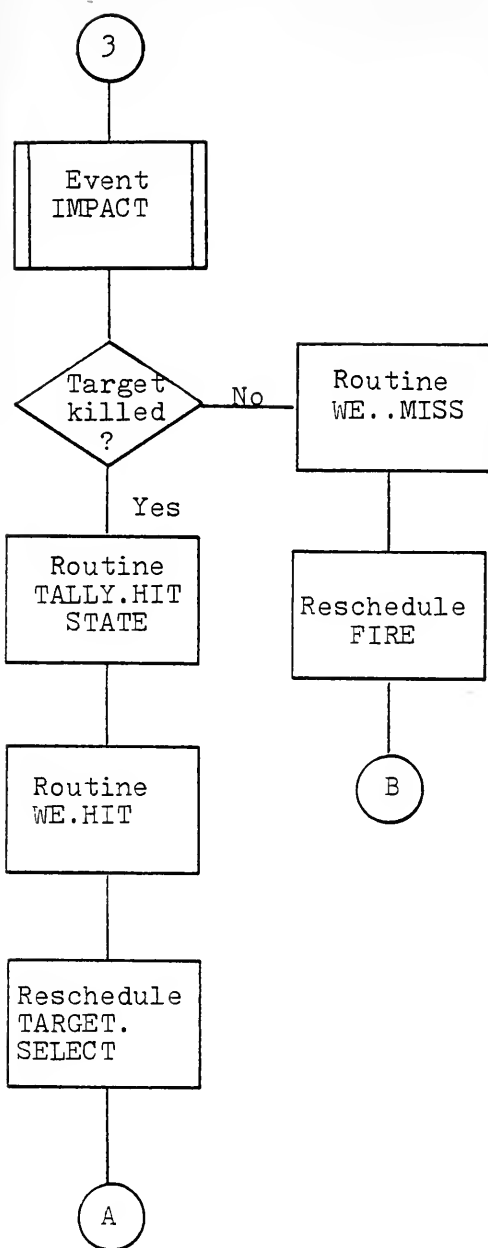
Explanatory text accompanies the flowchart. For details concerning the processing within an event, see Chapter IV.





After cycling through the PREAMBLE and MAIN, TANK goes into event STEP.TIME and looks at every opposing weapon system still active in the simulation. If time to detect determined by Routine CARDIO is less than or equal to 30 seconds, and line of sight exists to the target, the target is scheduled for detection. In any case next STEP.TIME is scheduled.



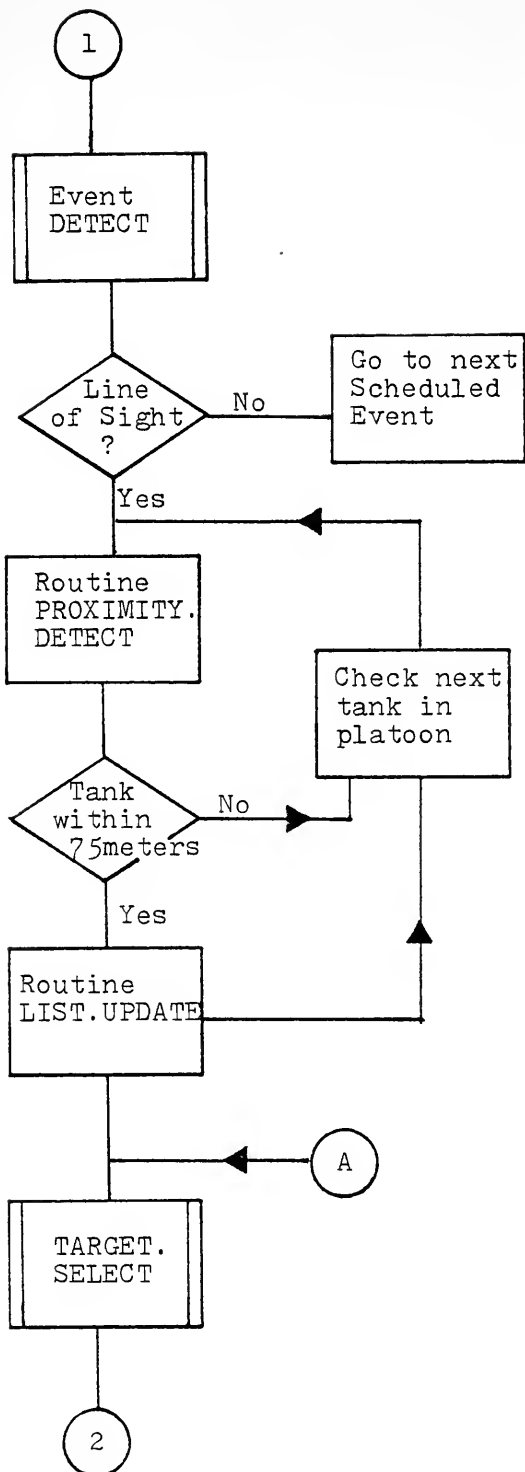


Routine IMPACT occurs at the time specified in event FIRE based on the time of flight of the projectile. Determination is made as to whether the round hits or misses the target, and the proper routine is called to tally the result of the round. If the round was a miss, the target is engaged again by rescheduling event FIRE. If the round is assessed as a hit, the firer selects a new target by scheduling the event TARGET.SELECT.

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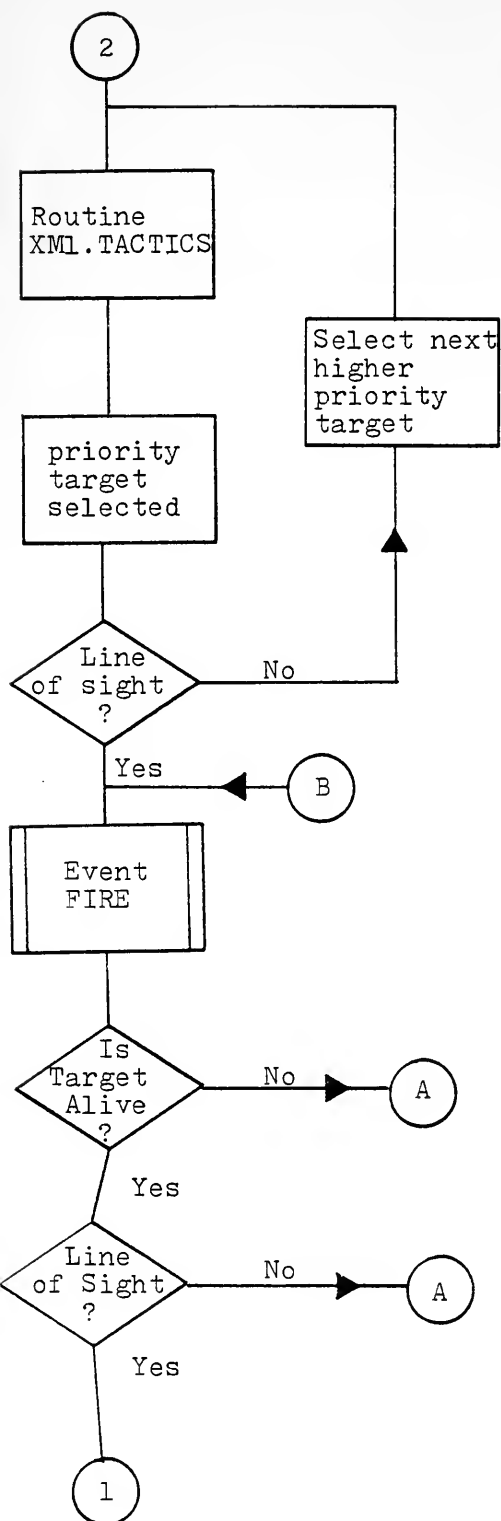
•



Event DETECT takes place at time scheduled in event STEP.TIME. Event DETECT first checks to see if line of sight exists between firer and target; if so, routine PROXIMITY.DETECT is called which checks all weapon systems in the detected vehicle's platoon. Routine LIST.UPDATE is called for the detected vehicle and any proximity detections. LIST.UPDATE places targets in the firer's list of currently detected targets and schedules event TARGET.SELECT.







Event TARGET.SELECT cycles through the firer's list of currently detected targets. For the XML, routine XML.TACTICS is called to determine if any other platoon member is scheduled to fire at the XML's highest priority target. The priority target is selected and line of sight is checked to see if it still exists between firer and target; if so, event FIRE is scheduled; if not, the next priority target is selected and the process is repeated. Event FIRE first checks to see if the selected target is still alive and line of sight still exists to the target; if so, the event IMPACT is scheduled to occur; if not, event TARGET.SELECT is scheduled.



## APPENDIX B

### GLOSSARY OF TERMS AND ABBREVIATIONS

- APDS - Armor Piercing Discarding Sabot; an armor defeating tank round
- ATGM - Anti-Tank Guide Missile; general term referring to wire guided missiles
- BLUE - Term referring to friendly forces in battle or simulation
- BMP - Warsaw Pact mechanized infantry carrier
- BN - Abbreviation referring to Battalion organization
- Bushmaster - 25mm automatic weapon mounted on U.S. Infantry Fighting Vehicle
- CO - Abbreviation referring to company organization
- DIVAD - Division Air Defense Gun; a tracked air defense weapon soon to be introduced into U. S. inventory
- DRAGON- A medium range, wire guided, anti-tank missile
- FO - Abbreviation referring to an artillery forward observer
- HEAT - High Explosive Anti-Tank; a tank round
- IFV - Infantry Fighting Vehicle; new U. S. infantry carrier equipped with an ATGM system and Bushmaster
- Inf - Abbreviation referring to Infantry forces
- M113 - Present generation infantry carrier
- Mech - Mechanized; used normally to refer to mechanized infantry forces
- MG - Abbreviation used to refer to any machinegun
- PLT - Abbreviation which refers to a platoon organization
- RED - Term referring to enemy forces in battle or simulation



T72 - Warsaw Pact main battle tank

XM1 - New generation U. S. main battle tank

ZSU - Warsaw Pact air defense weapon system



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